

Progress Report of Forest Research
Work in India

For the Year 1921-22.

Including the Administration Report of the
Forest Research Institute, Dehra Dun.



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Photograph showing *Cinnamomum Camphora*, coppiced and kept out in "ele-buck" form.
The trees have been kept out in "ele-buck" form for several years and are now in the process of being cut out.

INTRODUCTION.

This report deals with the period from the 1st April 1921 to the 31st March 1922 and is therefore the first dealing with the full period of 12 months since the abolition of the Forest Year (1st July to 30th June).

At the Silvicultural Conference held at Dehra Dun in January the question of the most suitable headings came under discussion and these now adopted were recommended in Resolution No. IX of that Conference's Proceedings. It is hoped that this will be considered an improvement. At all events it is now easier to compile the information under appropriate heads, but there is still room for clearer correlation of the work within provinces. In some cases the provincial reports can be embodied without alteration, in others it is necessary to curtail the information considerably. It is sometimes difficult to follow up experimental work which has already been referred to in previous reports and to distinguish between important and other matter. Until research officers are appointed in all provinces this condition will obtain but it would add considerably to the value of the report if the material could be supplied in a form suitable for direct incorporation. This report is intended to represent the progress of forest research work in India and includes the administration report of the Central Institute. It is not intended to be merely the compilation by this institution of matter which it considers of general interest.

It is to be hoped that the provinces will all co-operate in making the report fulfil its purpose and this, it is thought, can best be achieved by local preparation of the material. Eventually this may necessitate the allotment and perhaps curtailment of space but until the provinces are all equally equipped it is felt that too rigid a form is inadvisable.

The general impression conveyed by a perusal of the material forwarded is that an awakening is taking place in the department generally, in all scientific and economic directions. This is particularly the case in experimental silviculture in every province but the interest of the public in all questions of utilization is equally gratifying. The combination of research into problems of production and utilization, if continued and encouraged, must result in a fuller realisation of our forest resources which, after all, is the main object in view.

Some contributions from the United Provinces, Assam and North-West Frontier Province were received too late for insertion.

Progress of Forest Research in India 1921-22

CHAPTER I.

GENERAL.

Progress in the appointment of staff for research work and in the provision of appliances (buildings, equipment, etc.) has been retarded owing to the financial stringency. In some provinces the shortage of officers has precluded the filling of vacant posts. The following extract from the Burma report explains the position in that province :—

“ It may be mentioned that it is hoped to start construction of the quarters for Research offices connected with the proposed Research Institute at Maymyo within a few weeks and to have the Institute well under way by 1923.

The most important event of the year, so far as Economic Research is concerned, was the visit to Rangoon of the Forest Economist, Mr. Pearson, and a conference of senior officers who met him and decided finally the scope of the operations desired by the Forest Department. The recommendations of this Conference, have been sent up to the Local Government for approval and it is hoped that they will be sanctioned in full.”

At the Central Institute at Dehra Dun good progress was made in the construction of workshops and laboratories and the complete transfer should be effected before the end of March 1923.

The method of dealing with the general scheme of extension received careful consideration and orders were passed, after the close of the year, to proceed with the transfer of the Economic and Entomological branches to the new site. This is as much as can be expected in present circumstances and will have the desirable effect of clearing part of the existing Research Institute building for education. Both education and research will benefit greatly from this decision.

The sections of Wood Technology and of Systematic Botany were instituted during the year but it was not possible to organise the section of Wood Preservation owing to the difficult financial

position. This is to be regretted as it is probably more in this direction than in any other that a study of Indian problems is required. The experimental plant has been in Dehra for some time and it only awaits an expert to erect and work it in order to extend the use of Indian timbers and to replace the creosoted railway sleepers imported from other countries.

Allusion has been made to the Silvicultural Conference held during the year. An Utilization Conference was held concurrently; both were well attended and should prove of great value. The discussions dealt with general problems of organization of forest research rather than with specific problems and also aimed at the definition of the respective spheres of the central and local research organizations. The Proceedings have issued in print since the close of the year.

CHAPTER II.

SILVICULTURE AND WORKING PLANS.

Central Institute.

I.—Experimental Silviculture.

General.—The bulk of experimental silviculture in those provinces where local silviculturists have already been appointed, is done by them. The Central Institute has been passing through a transition period during the year and the sub-division of labour between it and the local silviculturists is only now becoming defined. It has been proposed and approved by the Silvicultural Association that, as a result of past experience, in the realm of pure experimental silviculture, the Central Institute should confine itself to recording and ledgering all experimental work in provinces and that its actual experimental researches should be confined to the seeds and seedling stage only. Once the plants get beyond this stage the local officer is the only person who has the facilities for carrying out the work, but where possible, the Central Institute should conduct such check experiments as provinces may ask for.

Natural Regeneration.—None of the natural regeneration experiments in the hills, dealing with hill types, have been visited during this year. It is not possible for the Silviculturist to visit all the plots yearly and it is partly for this reason that it is proving better for such work to be done by local officers.

*Sal (*Shorea robusta*).*—An attempt is being made to regenerate sal on the Gorakhpur method in Thano forest, which is subject to frost. The shoots were killed back early in 1921 but during the rains it looked as if they would get through. Grazing by deer & cattle proved so bad however, that when last seen, almost every plant was nibbled down to a height of about 3 feet. As grazing

incidence is not being tested, the area was fenced early in March 1922. The only other natural regeneration experiments on this species were in coppice experimental plots. These are being classified and the results obtained will be available shortly. From measurements made it appears again that the "coppice with standards" method is a poor one if anything much is expected from the coppice. Either simple coppice or high forest appear preferable, in the localities dealt with, with the exception perhaps of forests where severe damage from frost is expected.

Dalbergia Sissoo.—For some years an attempt has been made to regenerate sissoo by means of an ordinary seeding felling. The experiments on this subject only confirm what was already known, viz., that sissoo cannot be naturally regenerated in this way. An even heavier felling has now been made but it is not expected that any regeneration will appear.

Dalbergia latifolia.—Stems thinned in a local plot have all sent up vigorous coppice shoots.

Seeds.—The results of investigations into the weight of seeds have been published during the year.

The following results, on plant per cents (by this is meant the percentage of seedlings to seeds sown) have been observed during the year. It was an exceptional year however in Dehra Dun, as there was an abnormal hot weather, and no regular rain till July 7th. The beds were watered but the nursery was not provided with shades so that a large number of failures of species sown in May occurred which would not have happened in a normal year. In most cases the sowings were not made to test the plant per cent. and as it is merely an incidental and single observation it is not inserted as a final result. Sowings of *Anogeissus latifolia*, *Cedrela Toona*, *Chickrassia tabularis*, *Ficus infectoria*, *Odina Wodiér*, *Quercus incana* and *serrata*, *Sapindus emarginatus*, *Swietenia Mahagoni* and *Terminalia Chebula*, made between the 15th and end of May, failed completely or produced only an odd plant or two.

The following were the observed results on other species. In many cases the reason of the low plant per cent. was that too many seeds were sown and there was no room for all the plants to come up.

Species.	Germination per cent.	Plant per cent. in bed.	Time to germinate in bed.	REMARKS.
<i>Acacia Catechu</i> ...	Not tested ...	27%	10 days to 7 weeks.	The bed was full. Sown May 22nd.
<i>Acacia arabica</i> ...	" " ...	20,	3 to 4 weeks	Sown May 22nd. The bed was absolutely full. There was no room for more.

Species.	Germination per cent.	Plant per cent in bed.	Time to germinate in bed.	REMARKS.
<i>Albizia odoratissima</i>	Not tested ...	20%	6 days to 5 weeks.	Sown 26th May.
<i>Bombax malabaricum</i>	" " ...	32%	One month ...	Sown 26th May.
<i>Buchanania latifolia</i>	" " ...	10%	6 to 9 weeks	Sown end May.
<i>Cinnamomum Cam- phora.</i>	Not finished ..	...	4 to 6 months	Sown in November. Germination still going on.
<i>Dalbergia Sisoo</i> ...	Not tested .	10%	1 to 2 months	Sown 26th May. The plant per cent. conveys little as the bed was absolutely full of plants.
<i>Dichopsis elliptica</i> ...	" " ...	87%	One month.	
<i>Eugenia operculata</i>	" " ...	13%	10 days to 7 weeks.	Sown 13th August.
<i>Garuga pinnata</i> ...	" " ...	31%	10 days to 2 months.	Sown 24th July.
<i>Gmelina arborea</i> ...	" " ...	40%	3 weeks to one month.	Sown 21th June.
<i>Melia indica</i> ...	" " ...	Good not worked out.	10 to 15 days	Sown 21st July. Plant per cent. was probably 100.
<i>Piptadenia oudhensis</i>	" " ...	17%	8 days to one month.	Sown 21th June.
<i>Podocarpus nerifolia</i>	" " ...	37%	6 days to 1 month.	Sown 19th August.
<i>Prosopis juliflora</i> ...	" " ...	10%	3 weeks to 3 months.	Sown May 25th. The plant per cent. conveys really nothing here. The bed was abso- lutely full of plants.
<i>Sapindus detergens</i> ..	" " ...	13%	6 weeks to 6 months.	Sown May. Soaked in cold water for 2 days before sowing.
<i>Schleichera trijuga</i> ...	" " ...	0%	15 days.	
<i>Shorea robusta</i> ...	100%	Not ob- served.	Abnormal this year.	The plant per cent. of all is usually 30-50.
<i>Terminalia belerica</i>	Not tested ...	Good not worked out.	6 weeks to 2 months.	Sown 21st May.
<i>Terminalia tomentosa</i>	" " ...	8%	10 days to 6 weeks.	Sown 4th June. Seeds not covered.
<i>Talearia indica</i> ...	" " ..	28%	to 3 weeks	Sown too late end of August.

Nursery work.—There is nothing to report this year except that the abnormal hot weather of 1921 showed the necessity of providing shades over a permanent nursery such as the Kaunli one. A very large number of the sowings to raise plants for various experiments or for the new Institute failed completely and it is probable that these could have been saved with shades. Shades similar to those used in Bengal have now been erected and it is hoped that the young plants will now be immune from the results of abnormal weather.

Artificial regeneration.—A large amount of work has been done in this section during the last few years and observations filed as the experiments were finished. The result is a mass of detail out of which it is impossible to get any tangible results without first reducing the observations to definite essentials. This work has been commenced and it is hoped that it will be completed during the coming year when it will be possible to regulate the future work better.

It was, however, abundantly clear that in the matter of transplanting, etc., the experiments had practically always been made with too few plants, often only 5 or 6, and that there seems to have been no definite plan of work; experiments appear to have been haphazard and desultory. As a result it was decided this year to start a series of transplanting experiments with the following variations :—

- (1) Transplanting entire plants at the beginning of the monsoon.
 - (a) weeded round the plants.
 - (b) unweeded.
- (2) Root and shoot cuttings, transplanting at the beginning of the monsoon.
 - (a) weeded round the plants.
 - (b) unweeded.
- (3) Transplanting entire plants after the monsoon (usually November).
 - (a) weeded round the plants.
 - (b) unweeded.
- (4) Root and shoot cuttings, transplanting after the end of the monsoon.
 - (a) weeded round the plants.
 - (b) unweeded.

In every variation 50 plants will be used which, it is thought, is sufficient to give a reliable percentage of survivals. Five species have already been taken in hand and four more are being raised for the purpose.

The only one which has reached a definite stage is *Cinnamomum Camphora*, of which the following is the result to date.

Entire transplants July 1921, weeded,	
show now	80 per cent. survivals.
Entire transplants July 1921, unweeded,	
show now	48 per cent. survivals.
Root and shoot cuttings July 1921,	
weeded, show now	100 per cent. survivals.
Root and shoot cuttings July 1921, un-	
weeded, show now	94 per cent. survivals.

No other results can be given till the files have been sorted or till the new work is further advanced.

Dendrocalamus strictus.—A series of experiments with seeds, offsets from various aged culms, stem cuttings, etc., have been commenced but it is as yet too early to report. It appears that monsoon sowings, if weeded, or offsets from either one or two year old culms are an easy and successful method of propagation.

Reclamation and Afforestation.—The experiments in Zabarkhet grass land where there is great liability to heavy frost, foreshadowed last year, have been continued. The year 1921 was a particularly bad year for all winter sowings and plantings owing to the complete failure of winter rains, the severe drought in the hot weather, and a late monsoon. Consequently in a normal year much better results can be hoped for.

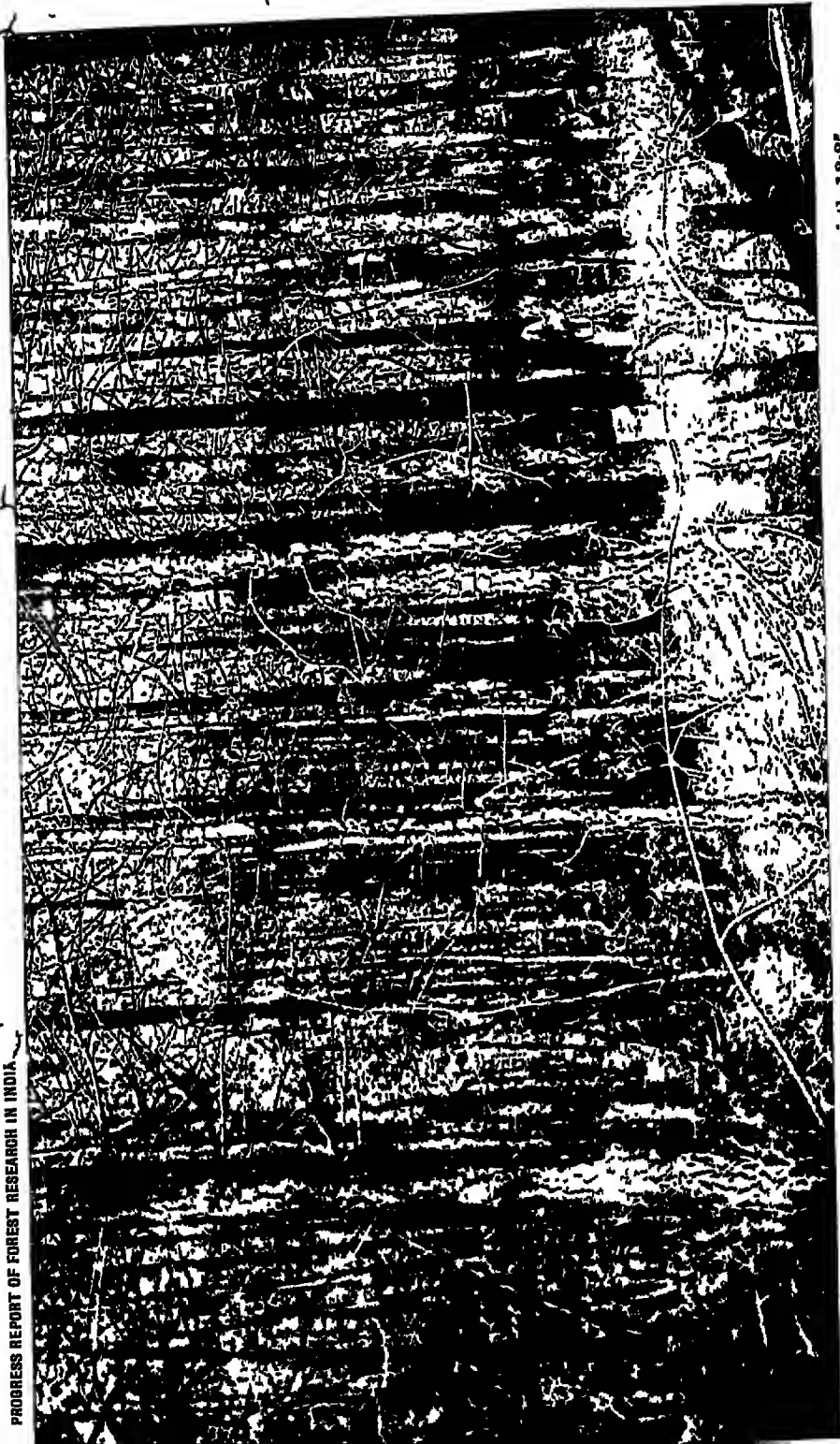
The following summarises the results.

Plot A.—Half acre, line sowing of *Pinus longifolia* on ploughed land in July 1920. No attention since. At present quite promising. A sufficiency of plants survive in the grass from 6 inches to 2 feet high. They are beginning to show new growth for this year. Pigs have done a great deal of damage.

Plot B.—Half acre, line sowing of *Pinus longifolia* in uncleared grass land in July 1920. Grass is very heavy but there are plenty of fine plants at present now showing new growth and slightly better than those in Plot A. Pigs have done damage in this plot also.

Plot C.—Half acre, sowing of *Pinus longifolia* on ploughed and cleared grass land in December 1920. No germination till the end of June (owing to winter rains failing) when the plants came up copiously. No weeding or attention in the rains. By November 1921 plants were 6" to 18" high. The grass was then cut as labour is available in that month and grass cutting pays for itself. Pigs have done damage but plants are thriving all over the plot.

Plot D.—(1) About 1½ acres burnt near on grass in November and root and shoot cuttings 4" size put out in rows at 5' x 5' interval in December. No further attention till the end of 1921 when the grass was cut. These cuttings were taken from the Song river bed and were gnawed and had to be cut up. Only 7 per cent. alive now but the grass is 1' high and there was no need



Photograph showing *untinnet* Sample Plot of *Pinus longifolia*, 29 years old, 1760 stems per acre, mean girth 13.3", mean height 31 feet, volume per acre 1592 cubic feet.

to cut the grass. In a normal year a better percentage could have been got but these river bed plants will not be used again.

Plot D.—(ii) Exactly as in D (i) but 225 cuttings from the nursery were used, which was all that were available. Now 47 per cent., alive are 3 feet to 4 feet high and very healthy. In a normal year a far better result would be obtained. Pigs have done a great deal of damage in this plot and have destroyed 10—15 per cent. of the plants.

Plot E.—As in Plot B but sown in June and July 1921.

Too early to report. Part of the area failed owing to bad seed but the rest looks promising and there are a good many plants to be seen on examination. Pigs have done damage.

Plot F.—About 1½ acres root and shoot cuttings of *Dalbergia Sissoo* exactly as in Plot D, but all plants obtained from a nursery and transplanted December 1921. A good percentage are shooting already but it is too early to give a definite percentage of success yet.

In addition, Plot D was redone and all new cuttings are sprouting. A record of originals and replacements has been kept. The root and shoot cuttings of *Dalbergia Sissoo* are as far as possible about as thick as the little finger or the thumb and with a root cut down to 6" and a stem to 2".

Thinnings and cleanings.—Nothing is being done except with reference to the ordinary statistical work or as reported under artificial regeneration.

Mixtures.—Nothing to report.

Underplanting.—Nothing to report. The experiment in underplanting *Pinus longifolia* with *Quercus incana* is being continued.

Silvicultural systems.—The only matter to report is the experiment in natural regeneration of sal under the Gorakhpur method mentioned under "Natural Regeneration." An attempt was made to try a sal taungya but it was so badly carried out that it was foredoomed to failure before it was sown and was therefore abandoned.

II.—Working Plans and Statistics.

(i) *Working Plans.*—The following working plans have been received during the year.

1. Revised Working Plan of the Casuarina Plantations, Alibag to Kolaba Division, for 1919-20.
2. Working Plan for the Sal Forests.
3. Revised Working Plan for Sal Forests.
4. Working Plan for the Sal Forests, Bihar and Orissa.
5. Working Plan for the Sal Forests in the Buxa Division of Bengal Forest Circle, for 1920-21 to 1925-26.

6. Working Plan for Jaunsar Bawar Forests.
7. Revised Working Plan for the Upper Hill Forest of the Darjeeling Forest Division, 1921.
8. Working Plan for the Yinke Working Circle, Upper Burma, Volumes I and II.
9. Working Plan for the Reserved Forests in the Jalpaiguri Division.
10. Working Plan for the Central Almora Division for 1920-21 to 1931-32.

A working scheme for the 250 acres of the New Research Institute was prepared and approved, but could not be commenced until administrative sanction to the scheme had been given.

(ii) *Yield Tables*.—The Central Institute has remeasured 18 plots this year on behalf of the United Provinces but the ordinary seasonal work does not fall within the year under report owing to the change in date. A great deal of spade work has been done in bringing old records up to date, all of which have to be converted from the old to the new methods and, though this work is not by any means finished, the greater part of it has now been done and the Bengal sample plots have all been worked out for the Bengal Silviculturist. No yield table has been published during the year. On the whole the new system of measurement and calculation is working well. It has already brought to light a large number of errors in former measurements (which is one of its principal merits) and results have now so progressed that it is believed that the compilation of proper crop yield tables for *Shorea robusta* and *Pinus longifolia* will be started early next cold weather, when Mr. Howard returns from leave, thanks, principally, due to the very excellent work done by the United Provinces on both these species. A hot weather tour was arranged for in the Punjab and it was hoped that sufficient data would be obtained to get out a Yield Table for *Cedrus Deodara*. Unfortunately the tour had to be abandoned owing to the unsettled condition of the Province. Certain difficulties have arisen with regard to calculations but in future these will be remedied by the Central Institute taking over all calculations so soon as the necessary staff is supplied.

As a result of experience gained, the Silvicultural Association recommended that, in future, all ordinary field work should be done by provinces and that all calculations should be done by the Central Institute staff; an arrangement which should tend to much greater speed and efficiency. It is impossible to obtain the necessary accuracy without having a staff continually employed on this rather special line of work.

(iii) *Volume and Form Factor Tables*.—Two volume tables have been compiled during the year, both for sal. One concerns I Quality Bengal sal only, the other is a general sal volume table.

The recording of all measured trees for this work continues and the rate at which results are coming in, is now so rapid that it is hoped revision of this year's sal volume tables can be got out in the coming year. Possibly also a volume table for *Pinus longifolia* and *Cedrus Deodara* can be issued.

(iv) *Bark Measurements, Heartwood Measurements, etc.*—These matters are recorded when possible and when data are collected for volumes and form factor. Information on these points and on lengths of marketable boles has been issued during the year.

III.—Publications (See Chapter VII).

IV.—Miscellaneous.

The Silviculturist toured in Madras in connection with the handing over of sample plots and discussed the future policy with the Madras Silviculturist.

The photographic collection now contains 4195 prints, 4108 negatives, 456 lantern slides, 6 colour positives and 3 cinema films. This represents an addition of some 540 negatives and 460 prints made during the year.

Assam.

General.—The enumeration and stock mapping commenced in 1911, with a view to ascertaining the contents of the evergreen forests of Assam has been continued. The results so far obtained would appear to indicate that approximately only 25 per cent. of the evergreen forests contain timber of marketable value. The remainder appears to consist chiefly of cane-brakes and worthless scrub jungle or forest in which trees of the more valuable kind are too scattered to render their extraction a paying proposition. There are practically no trees in these evergreen forests of outstanding value, such as the teak or sal, and none of the more valuable species is floatable so that export to the distant markets in Bengal cannot be done by floating, with the result that the high railway and steamer freights preclude the placing of Assam timbers on the markets of lower Bengal in competition with timbers of similar class imported from Burma or the Andamans. The local market is principally for tea-box timbers which is not capable of very great expansion. These facts must naturally affect the progress of Silviculture and of Working Plans and no great development can be expected until local markets have expanded and a demand arises for exploitation on a larger scale.

Natural regeneration.—In the Western Circle the experiments which were initiated in 1919 and referred to in the Progress Report of Forest Research Work in India for 1919-20, under Bengal and Assam, have been continued. These aim at the reduction of the evergreen undergrowth in the sal forests of the Goalpara Division by cutting and burning and at the same time reducing the overhead cover to 3—15 trees per acre. It has now been proved that a

grass undergrowth can be substituted for evergreen shrubs by these measures and, in the year under report, it is stated that there are a large number of healthy sal seedlings on the ground. These and modifications of the original experiments are in progress but it is as yet too soon to form any conclusions.

The effect of burning areas containing heavy *sao* grass (*Pollinia*) in the high level forests were observed with a view to ascertain whether any change in the character of the grass would result thereby. So far the experiment is hopeful.

In the Eastern Circle the experiments reported in last year's Report dealing with the following types of forests were continued:

- (1) Forests in which there is sufficient number of mother trees of the more valuable species.
- (2) Forests where there is an insufficient number of mother trees of the more valuable species.
- (3) Forests where valuable trees are absent.

In the first of this class the results have been fairly satisfactory but unfortunately the revelation that this type of forest occurs only over a very small area renders these experiments less hopeful than was originally expected. The necessity of weeding has become apparent, specially in those areas where insufficient overhead cover has been maintained, and it would appear that the success of these experiments from the financial standpoint must depend on a careful reduction of overhead light to that in which the seedlings best thrive. The report shows that the species enumerated in last year's Report have continued to give satisfactory results although it is not clear whether *Phoebe attenuata* has developed as quickly as its associates. The above results show that the clearing of the undergrowth and the reduction of the overhead cover, followed by burning of the slash, does undoubtedly produce successful re-generation, and it will be necessary to systematise the work in order to reduce the cost of soil preparation and subsequent tending.

Seeds, etc.—Experiments to test the germination of the seeds of different species have been carried out in the Lakhimpur and Sadiya Divisions. In the former the seed of *Albizzia lucida* and *Bischofia javanica* gave cent. per cent. germination. The results in the Sadiya Division on the other hand vary greatly, although in some instances the seed is supposed to have been collected unripe, in others the cause of failure is as yet unknown.

* *Artificial regeneration.*—The Taungya plantations for the production of *Bombax* for the tea-box industry, which were commenced a few years ago in the Lakhimpur and Sadiya Divisions, have been continued but it is a question whether this tree is of much value now that the utilization of other kinds in the form of 3-ply boxes has been undertaken on a large scale. Other and more valuable kinds have therefore been substituted for *Bombax* during the year under report: but it does not appear as if there would be as easy to cultivate successfully in temporary cultivation as *Bombax*.

Underplanting.—This is considered one of the most important experiments, for, as explained above, about 25 per cent. of the total area of the evergreen forests will have to be regenerated artificially and it is believed that this can best be achieved by underplanting. Most of the valuable species are shade bearers and this attribute is valuable in order to avoid the mass of weeds, including *Eupatorium*, which invariably appear in clearings. Success has been attained with *Bischofia javanica*, *Lagerstroemia Flos Reginae*, *Amoora Wallichii*, *Dysoxylum procerum*, *Phoebe attenuata*, and *Artocarpus Chaplasha*.

The plantation of *Aquilaria Agallocha*, which is the source of the valuable product known as *agar*, was continued. Other valuable species have also been taken in hand and the observations made in the forests of *Terminalia myriocarpa* in the Frontier Tract, in which heavy fellings have been carried out, would appear to indicate that this species also can be regenerated by sowing or planting and that it is not essential to burn the undergrowth provided that the mineral soil is sufficiently exposed. The relative growth and development of the different species under this method of treatment is being observed and it would appear that *Cedrela febrifuga* produces the quickest growth, reaching a height of 10 feet in three years.

Silvicultural systems.—The fact that so much of the evergreen forests is worthless precludes the adoption of any but the system of artificial regeneration for the bulk of the forests and present indications point to some such simple system as the *quartier bleu* as the most suitable.

Volume and form factor tables.—Volume and form factor tables are in course of preparation.

The report on research work carried out in the Cachar Division was received too late for insertion!

Bengal.

Natural regeneration.—In north Bengal, in the moist forests of the hills and plains, natural regeneration of the species of some value is practically absent. In the plains forests of the Kharseong Division, on areas which are not clear felled, regeneration of three evergreen shade bearers is found, viz., *Amoora Rohituka*, *Amoora Wallichii*, *Dysoxylum binectariferum* and in the ungrazed hill forests *Acer Campbellii* and *Evodia fraxinifolia*. In the plains on clear felled areas *Anthocephalus Cadamba* and *Trema orientalis* come in by seed, *Sterculia villosa* and *Callicarpa arborea* by coppice shoots; in the clear felled areas of the hills *Macaranga* spp. and *Evodia fraxinifolia* come in by seed, *Symplocos theurifolia* and *Eurya* spp. by coppice shoots.

Natural regeneration of *Heritiera minor* and many other species is prolific in the Sundarbans.

Nurseries.—Nursery work in Bengal received special attention as usual, the object being to produce strong healthy plants, which will have every chance of success when put out into the forest and thus cheapen the cost of formation and tending plantations. The nurseries in the Darjeeling Division are especially well organised and cared for. Attention is drawn to the difficulty of assessing the area needed for nurseries if early and complete success is to be obtained in filling up blanks.

Artificial regeneration.—Of the work which has been done up to date in northern Bengal, Bulletin No. 5 by the Silviculturist, Burma, gives a very good idea. Wherever possible the taungya system is used, the crops being grown by the taungya cutters. Where taungya cutters are not available, plantations are made and the crops grown by departmental agency, as at Panchanai in the Kurseong Division, or the plantations are made departmentally and no crops are grown, as at Rajabhatkhawa in the Buxa Division. With regard to the system of departmental crops, the following figures given for Panchanai show that this is expensive :—

			Rs.	l.	p.	
1st year	...	...	34	9	0	per acre./
2nd year	...	...	9	10	0	"
3rd year	...	...	7	0	0	"
Total	...	...	51	3	0	
Cost of fencing	...	...	63	0	0	"
Total	...	...	114	3	0	per acre.

Two conclusions may be drawn from these figures—

- (a) That departmental crops must be made to pay.
- (b) That unless a cheaper form of fencing can be devised, the injurious game will have to be dealt with.

At Rajabhatkhawa as yet it has not been possible to put in departmental crops or to get outside cultivators to come in, but a start has been made in the present year with small areas under cotton and maize, the former by an ex-forest guard and the latter by the department. If these experiments are successful it is hoped that cultivators will sow all the crops in future. The cost per acre excluding fencing and special staff amounts to Rs. 36. As the areas to be restocked are large and compact, being the areas cleared by the Buxa Trading Company, the cost of fencing is far less than at Panchanai.

A new development at Rajabhatkhawa is the direct sowing of species other than sal which for the most part had previously been transplanted from the nurseries, notably *Lagerstroemia Flos-Reginae*, *Cedrela Toona*, *Acrocarpus fraxinifolius*, *Bombax malabricum*, *Bischofia javanica*, *Chickrassia tabularis*, *Morus laevigata*. All these species are being sown in lines six feet apart and results are hopeful

so far. Up to the present, mixtures of *Bombax malabaricum* with *Bischofia javanica* and again of these with *Michelia Champaca*, and *Cinamomum cecicodaphne* and *Gmelina arborea* as pure crops have 'done best.

In the Darjeeling Division winter planting has been carried out and complete success has been obtained with *Acer Campbellii* and *Prunus nepalensis*. *Quercus lamellosa*, *Bucklandia populnea*, *Alnus nepalensis*, *Eriobotrya petiolata* and *Mathilus* spp. have been tried for one year. Of these the first two are alive and healthy, the third is alive but sickly and the other two have died. No definite conclusions can be drawn yet. If winter planting can be carried out successfully the cost of making plantations will be diminished materially, for the seedlings will get a better start in the spring and get further ahead of the weed growth and in this way casualties will be reduced.

Silvicultural systems.—Those prescribed by the latest Working Plans are still under observation. Progress in placing the full areas under clear fellings, especially in the moist forests of the plains and hills, is greatly retarded by the difficulty which is experienced in obtaining labour to restock the cleared areas. As a result only the better localities are being planted or sown. The remaining areas are being allowed to come up in coppice, together with any natural regeneration that may be present. This is considered to be a good system and in the northern Bengal Divisions it will provide fuel and box-planking which is greatly in demand. Sixteen acres of the Hateswar coupe in the Kurseong Division have been allowed to grow up in this way, and it is now nearly fully stocked principally with seedlings of *Trema orientalis*; with a little climber cutting this will be established at a very low cost and should provide good firewood in 15—20 years and fair box-planking in 30 years.

Working Plans and Statistics.

1. *Sample plot work, etc.*—The work of remeasuring sample plots was continued throughout the year. The following figures have been made available by the Silviculturist, Dehra Dun :—

Species.	Age.	Average height.	Average diam.	Average volume. Stem. Small-wood.	Average volume. Stem timber.	Average annual increment.	Locality.
<i>Bucklandia populnea</i> .	14	Feet. 38.3	Inches. 5.00	Cu. ft. 1171.3	Cu. ft. ...	Cu. ft. 122.86	Mungpoo Cinchona Plantations—Hill Forests
<i>Bucklandia populnea</i> .	10	33.6	3.00	838.0	...	86.90	
<i>Betula cylindrostachys</i> .	6	48.0	4.0	1829.0	...	271.30	
<i>Betula cylindrostachys</i> .	7	43.0	5.40	2079.0	...	297.00	
<i>Cryptomeria japonica</i>	27	78.0	13.50	752.0	3508.0	168.5	

2. *Volume and yield tables, etc.*—From measurements taken in the Toong taungya, Kurscong, elevation about 5,500—7,000', the following figures for height growth have been obtained :—

Species.	1st year.	2nd year.	3rd year.
<i>Alnus nepalensis</i> ...	2'—3'	8'—0'	12'—14'
<i>Cryptomeria japonica</i> ...	1'	2'—3'	4'—5'
<i>Bucklandia populnea</i> ...	8'—1'	2'	4'—5'
<i>Juglans regia</i> ...	1'	4'	8'—10'
<i>Eriobotrya petiolata</i> ...	1'	2'—3'	4'—5'

Bihar and Orissa.

Again no research officer could be appointed owing to the shortage of gazetted officers. The Divisional officers could devote very little time to research work after doing their routine duties. The following is a resumé of such research and experiments as could be carried out by the Divisional Forest Officers, Singhbhum, Hazaribagh, Puri and Angul in their respective divisions.

1. An experiment in the cultivation of field crops with sal in Valley Type areas was attempted, the field crops (rice) were wiped out by wild elephants so that the result was a failure.

2. An experiment in the propagation of *Vitex peduncularis* by cuttings proved only partially successful. Seed of this species sent to the Malay States and Assam did not germinate.

The experiments in connection with the regeneration of sal in the mixed evergreen forests of the Banpur Mals in Puri Division are still being continued. The experiment which was inaugurated in 1920, consisting of entirely clearing away the underwood and undergrowth and at the same time opening the over head cover of sal trees, has given very satisfactory results. The ground is covered with sal seedlings which may be counted on as fully established. They have passed through the vicissitudes of two comparatively dry seasons and have shown no tendency to die back, but on the contrary are pushing ahead with a rapidity that will soon place them out of danger of the rank growth of grass and weeds which springs up with the advent of the monsoons. The time has now come to remove the mother trees which were left scattered over the area.

In continuation of the above, four other experiments were undertaken during 1921, also in connection with sal. This consisted of opening the canopy (both above and below) to varying degrees of density, keeping the plot of 1920 as the extreme case. The results clearly show that the regeneration varies from place to place according to the degree of light admitted, and has established the fact that sal

regeneration can be obtained to best advantage in this climate by complete exposure. These experiments give a definite indication of the method of treatment to be adopted in the sal areas.

Casuarina.—It was noticed that *Casuarina* seedlings contained a peculiar nodular growth on their root systems which somewhat resembled the nodules which occur on plants belonging to *Leguminosae*. Specimens were sent to the Forest Botanist at Dehra Dun for examination and he now reports that the plants contain numbers of bacteria which help to fix nitrogen from the air. Investigations are now in hand to ascertain at what depth in the soil the nodules are usually found, and what factors appear to encourage the formation of nodules.

Teak seed buried in the soil close to white-ant heaps for a period of 1 month prior to sowing gave germination within one week of sowing and produced healthy seedlings. The seed which will be sown this year has now been buried for nearly one year, and the results of germination will be reported in due course.

Experiments are in progress in Angul Division in order to ascertain the dying back phenomenon of sal seedlings. Two plots each 15' square have been selected. One of them is in shade while the other is in the open. Both of them have been fenced round with a bamboo fence. Every other growth except 1 year old sal seedlings has been removed. A sal seedling with two leaves has been taken as 1 year old seedling. All these seedlings were counted and entered. Countings are done every fortnight and the results noted. As this experiment was started in January 1922 it is too early to say anything definitely.

Experiment was started in order to ascertain the height increment of ruppia shoots, before and after the rains. Unfortunately the area selected was not fenced with the result that deer destroyed the young shoots. This experiment will be started again during 1922-23.

Bombay.

No information forthcoming.

Burma.

General.—At the commencement of the year the Silviculturist was engaged on a tour in Katha Division where work under the Mohynin Working Plan was inspected. This work has not progressed as satisfactorily as might have been hoped. From the end of May until the early part of August tours were made throughout Thuraia-waddy, Zigon and the southern end of Prome Division, followed by a short tour in the Delta forests on which a note was drawn up in collaboration with Mr. A. W. Moore, O.B.E. Early in September the writer proceeded to Dehra Dun in order to become

acquainted with the methods of Ledger filing and Record keeping as practised at the Forest Research Institute. A short visit was also paid to Naini Tal where research and working plan methods in the United Provinces were studied. The writer returned to Burma at the end of October.

In the middle of November the cold weather tour commenced with a visit to the Pyinyang forests in Meiktila Division in order to advise on the best methods of regenerating the forests there in view of the commencement of a jungle wood lease. The teak plantations at Pyonehaung in North Toungoo were then visited followed by a visit to the regeneration area in the Saing Yene forests which are being worked by clear felling under a jungle wood lease. The regeneration area at Putkya was also visited. The greater part of December was spent in the Tharrawaddy Division. The results of experiments carried out at Nyaungbinzin were first inspected and then a commencement was made in laying out permanent sample plots in teak plantations in Minhla Reserve and in the training of the sample plot party under Ranger Maung Kaw Wun. During January and the early part of February the Silviculturist was absent in India, first attending the Silvicultural and Utilization Conferences at Dehra Dun and then on a most interesting tour in North Bengal, mainly with a view to seeing the Bengal nursery methods. The latter part of February and the first half of March were spent in Tharrawaddy and Zigon Divisions, first in inspecting sample plot work done and making thinning in the sample plots and then in organising a series of experimental plots and a small sample nursery on Bengal lines. At the close of the year a commencement was made with a tour in Katha Division.

Owing to there being no satisfactory office available and to the absence of the Silviculturist on tour or on deputation to India, little progress has been made with the important branch of record keeping and Ledger filing. Since the close of the year however a more satisfactory arrangement for a temporary office has been made and it is hoped to make a start during the coming year in the organisation of a Library and Ledger files.

Mr. H. S. Single, Assistant Conservator of Forests, on appointment in December, was attached to the Silviculturist and towards the end of the year was employed in laying out a series of experimental plots in regeneration areas in Nyaungbinzin Reserve, Tharrawaddy Division.

Maung Kaw Wun, Ranger, was attached to the Silviculturist from August until the close of the year. He accompanied the Silviculturist to Dehra Dun in September and studied the latest sample plot methods at the Research Institute for a month. From December to the close of the year he has been in charge of the party engaged on the laying out of sample plots and has shown that he can now be thoroughly relied on to select and lay out sample plots by himself. In future, progress in sample plot work should be more

rapid now a sample plot party has been organised. As soon as another reliable Ranger can be obtained it is hoped to form another party. Eventually it is hoped to have at least 4 parties working.

The position of the Burma Silviculturist is in some ways a difficult one. In the first place the area to be covered is enormous, the problems to be tackled are numerous and it is quite impossible to see more than a small portion of the work that is being carried on. This would not matter so much if he were, free to concentrate on definite problems and devote himself entirely to experimental and statistical work instituted and carried on by himself. Unfortunately he is also expected to act as a general adviser and to keep in touch with and advise on practically all regeneration and silvicultural work being carried out in the Province. The result is that while it is quite impossible to inspect all the areas that should be inspected, the necessity of covering as much ground as possible seriously interferes with his more legitimate experimental and statistical research. Under the present circumstances therefore the sum total of actual experimental and statistical research carried on must be somewhat disappointing, as most of the Conservators consulted agree that touring and inspecting work in the Divisions and advising thereon must for the present form an important part of the duties of the post. Eventually the Branch must expand and the actual experimental and statistical research must be carried on by assistants under the guidance and supervision of the Silviculturist who will also be free to inspect and advise on silvicultural work generally.

I.—*Experimental Silviculture.*

General.—Some progress has been made in the methods of laying out experimental plots in young crops. The necessity of obtaining results which were not dependant entirely on observation but could definitely be reduced to figures was early discovered. As a result the method now adopted is to lay out small one chain square plots in pairs or threes under as similar conditions of soil, aspect, slope, etc., as possible. Each plot is treated so that the plots will show clearly the results of one particular operation only. The best method of reducing these results to definite figures in the case of regeneration has been found to be by enumeration and measurement of the height growth of all seedlings on the plots before, and again at intervals after, the operation, with which the investigation is concerned, has been carried out. A comparison between the rate of survival and the height growth in the different plots gives a very good indication of the benefit or otherwise of each operation. A number of plots have been laid out on these lines during the year and it is hoped that definite results on many questions affecting the earlier stages of regeneration will be forthcoming.

Natural regeneration (including coppice, rootsuckers, etc.)—Little work has been done in connection with natural regeneration during the year. Natural regeneration is not at present of

much importance in the main bamboo forests in Burma and during the year it was not found possible to do any work in connection with *Dipterocarps*. Since the close of the year the natural regeneration of *D. turbinatus* (*kanyin*) and *D. tuberculatus* (*in*) has been studied and experimental plots are being made.

The year 1921 was an excellent seed year for *Pentacme suavis* (*ingyin*) in Katha Division. Seedlings germinated in thousands in many parts of the Division owing to favourable early rains. Examination late in the rains however showed that nearly all these seedlings had died back. A further examination since the close of the year under report would seem to show that considerable light is essential for the successful regeneration of *ingyin*. Wherever reproduction had sprung up under shade the seedlings had not been able to grow vigorously or to form the carrot-like taproot that is so essential for survival. In the absence of direct overhead cover, but where the gap in the cover was not big enough to encourage the vigorous growth of weeds, the *ingyin* seedlings had survived and were healthy. They had all developed carrot-like taproots and the majority of them had not died back. Where weeds had been encouraged by the opening out of the cover to a greater extent the *ingyin* had invariably been smothered and killed.

Seeds.—The distribution of seed has again been arranged for in all cases where seed of any particular species was unobtainable in the Division in which it was required.

The supply of seed to countries outside Burma was also arranged for where possible.

A new method of separating *Adina cordifolia* (*hnaw*) seed from the husk has been found by Mr. Dawkins. After the heads of seed have been collected and dried the heads are broken up and immersed in water. After stirring up and allowing to settle it is found that the seed all sinks to the bottom leaving the husk floating. The husk and water are then poured off and the residue, which is almost pure seed, can be dried. The same result can be attained by winnowing. In the past sowing of *hnaw* seed has frequently been unsuccessful and the probability is that the empty husks were sown.

Nursery work.—As a result of the Silviculturist's visit to Northern Bengal sample nurseries on the Bengal lines have been started in Zigon Division and in Maymyo. Since the close of the year a nursery has also been made to supply plants for the regeneration area under the Molmyin Working Circle. While there seems to be a great future for nursery work in the evergreen forests of Upper Burma and especially in connection with the planting of Eucalyptus in Maymyo it seems doubtful if there is much scope for it in connection with the deciduous teak forests of Lower Burma.

Artificial regeneration. Teak.—The method of broadcast sowing in the taungyas soon after burning and the later transplanting of

early germinated seedlings to stake has continued to give good results and has proved to be a most popular method with the taungya cutters in Tharrawaddy Division, as it does not entail a race against time to complete the staking and sowing at an early date. Mr. Dawkins has introduced another method in his taungyas in Zigon. A small furrow about 1' long is dug up to the depth of 6" and the soil thoroughly loosened and replaced. The seeds are then pressed into the loosened soil. On the level or on easy slopes this method has been found to give most excellent results both in germination and growth, but on the steeper slopes there is danger of the loosened soil being washed out of the pits and other methods are necessary. At the same time it must be admitted that this method adds considerably to the work that has to be done by the taungya cutters even though in the case of Zigon Division an increased spacing of 9' x 9' has reduced the number of stakes per acre by over 50 per cent.

Further experience of the use of buried seed shows that the results are extremely uncertain. The majority of buried seed examined during the year was found to be bad. While no doubt buried seed which has kept good does germinate very rapidly, the loss of the thick corky covering of the fruit is not altogether an advantage. The two essential preliminaries to successful germination are heat and moisture. In the case of buried seed that has had its corky covering eaten by white ants the fruit is instantly dried up by the heat of the sun as soon as rain is over. In the case of seeds with the corky cover intact, this retains the moisture which is further acted upon by the heat of the sun, producing conditions suitable to germination.

Further experience has shown that the use of teak stumps requires considerable care in order to give satisfactory results. Experiments are now being undertaken to ascertain the best size to plant and the best time of planting. The previous directions given in Burma Forest Bulletin No. 3 have proved that the season given as the best time for planting teak stumps, i.e., early May, is wrong as the rain after planting is too uncertain. Generally speaking stumps should not be put in until continued rain for 2 or 3 days is fairly certain. Stumps have been planted out in the late cold weather but have not proved very successful. It has also been found that when cutting the root care must be taken not to damage the carrot-like taproot.

The use of broadcast sowing of accessory species to complete the stocking with a view to reducing the cost of weeding is gradually extending. Apart from the reduction in costs it appears probable that the early formation of a dense stocking also leads to a very much more vigorous growth of the major species. The reason of this is undoubtedly that the clean soil produced by a heavy shade and absence of weeds and grass has a very beneficial effect both on the free development of the root system and by retain-

ing the moisture in the soil. Mr. Davis in his Annual Report for Tharrawaddy notes that small leaved and slender stemmed species like *Xylia dolabriformis* (pyinkado), *Lagerstroemia Flos Reginae* (pyinma) and *Terminalia tomentosa* (taukkyan), ought to be grown closer than 6' x 6'. He contends that a pure close crop is easier to tend than a crop with the major species at regular intervals and a dense stock between of accessory species. The writer does not agree with this view. It is surely easier to tend a crop in which one species only is to be favoured and whenever necessary the other species can be cut out.

Reclamation and afforestation.—The only important work of this kind in Burma is in the Bhamo Kachin Hills. Here excessive taungya cutting combined with uncontrolled burning has converted a comparatively well wooded country into a waste of bracken covered hills. The elevation is between 4,000' and 6,000'. In 1921 an area of some 200 acres was sown up after burning with *Alnus nepalensis* (maibau) which is sown by some of the neighbouring tribes in their taungyas in order to re-cover the areas rapidly with forest growth. Besides growing very rapidly the humus produced by this species is said to improve the soil better than any other species. Part of the area was sown at a spacing of 6' x 6' in small pits and part was sown broadcast. Of the two the broadcast sowing was much cheaper and equally successful. Unfortunately the frost early in 1922 was exceptionally severe and all the seedlings on the lower slopes were killed back. On the higher slopes where the frost was not so severe, the seedlings mostly survived and appeared to be quite healthy under the dense shade of the bracken. Fire protection of the sown areas is essential as portions of the area sown in 1921 have been burnt with complete loss of all regeneration. The most urgent problem that remains is to discover a good rapid growing frost hardy species for sowing on the lower slopes where frost damage is bad.

Thinnings and cleanings.—Research into the best time to commence thinnings in young crops is extremely urgent. In Burma we have been finding that our older teak plantations show on the whole a disappointing growth and the individual trees do not seem capable of taking advantage of thinnings to increase the size of their crowns. In fact we find a condition of growth in the older plantations similar to that so ably described by Mr. Bourne in his Working Plan for the Nilambur plantations. The remedy is undoubtedly the same as Mr. Bourne lays down, i.e., early and repeated thinnings to allow the full development of the crown. Mr. Dawkins is instituting experiments in young teak plantations 4 to 8 years old to ascertain the effect of early thinning. In a 7 year old plantation over a small plot, trees were thinned down to 150 trees to the acre. The trees in this plantation averaged 37' in height and 15½ in girth. In a year they had increased over 2 inches in girth and had extended their crown appreciably. Trees

in unthinned plantation adjacent had only put on half this girth increment.

Miscellaneous.—Burning and fire protection.—This subject is of very great importance at present. It is not a question so much of the damage done by fire as the use that can be made of fire in reducing the cost of establishment of the crop. Mr. Dawkins has been investigating this question for the past two years and besides being a keen protagonist of early burning as against fire protection as a means of preventing damage, has also investigated the question of burning back the young crop of teak with a view to reducing the expence of weeding and establishment. This he is doing both before the 2nd and 3rd rains of the crop. A series of experimental plots has been laid out to compare the results of burning alone and of cutting back all weeds and shoots and burning, with fire protection. No results are yet available for areas cut back before the 3rd rains but some interesting results from plots laid out before the 2nd rains are available. They show the following results.

(1) As a result of burning the crop late only one weeding was required in the 2nd rains instead of twice as in unburnt areas or in early burnt areas. The cost of weeding was therefore halved.

(2) Although the percentage of survival in the area burnt late was slightly less than in the unburnt area, 86 per cent. as compared with 95 per cent., the average height of the teak seedlings was 49.8" as compared with 27.5" in the unburnt area.

(3) The burnt area showed fewer weakly seedlings at the end of the rains as compared with the unburnt plot.

(4) There was not much difference between the area burnt late and the area that had been cut earlier and then burnt at the same time as the uncut area.

The height growth even in the burnt plot is far below what can be attained by teak in two years' growth but the plantations were not of the best quality. The *taungyas* had been very badly weeded and the teak seedlings were weakly. It is however just in these conditions that burning seems to be most beneficial. Where vigorous teak seedlings with big leaves are obtained as the result of the first year's work, they are quite capable of looking after themselves and, whether they are burnt or not, shoot up rapidly in the second rains. It is the small seedlings with small leaves that cannot get a good start in the second rains and are rapidly suppressed by the weeds. Burning however gives them a good start and while checking the growth of the weeds causes the teak to send up strong shoots with big leaves.

From experience gained the writer has no doubt whatever that in the case of teak plantations that have not been given a good start in the first year burning is undoubtedly a great help and should always be done. In the case of plantations in which the seedlings are vigorous an early burning might kill off the weeds without

damaging the more vigorous seedlings, but for weakly seedlings a late thorough burning is probably preferable.

Mr. Dawkins' theory is that plantations burnt over before the 2nd rains need only be weeded sufficiently to prevent the seedlings being suppressed by weeds. The area is then either cut over and burnt or simply burnt in the following hot weather. It is too soon to say yet whether this method will result in a saving of expense or not but the results so far promise well. The result of burning is an early and vigorous growth of coppice shoots of teak which can keep ahead of the weeds and thus render any great expense of weeding unnecessary.

II.—Working Plans and Statistics.

(Sample plots.)

Yield tables.—Reports of all the older existing sample plots have now been received from the Divisional Forest Officers. With few exceptions they have mostly been discarded as useless. Only those made by the Forest Research Officer between 1914 and 1917 and a few, chiefly for girth increment only, made by Working Plans Officers, are of any use.

During the year 11 new sample plots have been made in teak plantations in Tharrawaddy and Zigon Divisions and 6 old plots have been remeasured and reorganised on the latest methods. One sample plot for ascertaining the girth increment of *Dipterocarpus alatus* was also remeasured. Progress was extremely slow owing to the difficulty of obtaining labour at any price. Most of the new sample plots made are in plantations of from 15 to 30 years old. This coincides with the period during which the area planted annually was at its maximum. Owing to the way in which taungya plantations were stopped from 1906 until the revival of planting in 1918 it is extremely hard to get sample plots in plantations between the age of 5 and 15 years. On the other hand, with the exception of one or two plots in really old plantations such as those at Myodwin and Kangyi, started by Sir Dietrich Brandis, it has so far been found impossible to obtain suitable plots in plantations made in the seventies or early eighties. Even the sample plots made are far from satisfactory in regard to stocking as it is almost impossible to find even half an acre of fully stocked plantation. The probable reason of this is that the older plantations were not sufficiently tended during youth and thinning has been started so late that the crowns have lost their vigour and are unable to develop and fill up gaps.

The following figures for girth increment, though based on only a limited number of trees in the natural forest and sometimes over only a limited period, may nevertheless be interesting.

Periodic mean annual girth increment (in inches and decimals).

Girth class.	<i>Gmelina arborea</i> (Katha) 12 trees.	<i>Protium serratum</i> (Katha) 95 trees.	<i>Lagerstroemia Flos</i> <i>Reginae</i> (Katha) 53 trees.	<i>Adina cordifolia</i> (Katha) 8 trees.	<i>Dipterocarpus alatus</i> (Thalawaddy) 68 trees.
1' 1" to 2' 0" ...	...	.3	.15	...	.57
2' 1" to 3' 0" ...	...	.40	.24	.31	.60
3' 1" to 4' 0" ...	.37	.47	.23	...	.61
4' 1" to 5' 0" ...	.48	.43	.20	1.23	.81
5' 1" to 6' 0" ...	.71	.85	.47	...	1.3
Mean annual increment	.51	.40	.23	.82	.63
Rotation based on mean annual increment to attain 6' girth.	141 years	157 years	257 years	88 years	101 years

Girth class.	<i>D. tuberculatus.</i>			<i>Ternstroemia</i> <i>lanceolata</i> Shwaga Division 17 trees.	<i>Pentacme</i> <i>parviflora</i> Shwaga Division 51 trees.	<i>D. turbinatus</i> Shwaga Division 32 trees.
	Mogoke Division 50 trees.	N. Tomigoo Division 103 trees.	Shwaga Division 127 trees.			
1' 1" to 2' 0" ...	.65	.13	.30	.26	.14	.33
2' 1" to 3' 0" ...	.30	.20	.21	.23	.30	.53
3' 1" to 4' 0" ...	.18	.31	.25	.37	.32	.37
4' 1" to 5' 0" ...	.16	.30	.21	.32	.21	.65
5' 1" to 6' 0" ...	.15	.32	.10	.31	.20	.45
6' 1" to 7' 0" ...	.21	.17	.24	...	.15	.27
7' 1" to 8' 0" ...	.14	.18	...	...	...	...
Mean annual increment	.17	.35	.28	.28	.27	.53
Rotation based on mean annual increment to attain 6' 0" girth.	424 years.	203 years.	313 years.	257 years.	207 years.	136 years.

Although these figures, especially for the species of which only a few trees are available, are far from reliable they do indicate roughly the relative rates of growth for each species. Unfortunately many of the old sample trees were badly chosen and were often dominated or suppressed.

Volume tables.—Data for rough outturn tables have been coming in from teak firms and from Divisional Forest Officers. Since the close of the year it has been found possible to issue a tentative volume table for teak in Tharrawaddy Division and it is hoped to work up further results later.

Central Provinces.

The outstanding feature of the year was the after-effects of the rain failure in 1920 and the exceptional and prolonged incidence of the hot weather of 1921. Over half a lakh of teak trees 1' in girth and upwards died in the Markhanda and Waingana Felling Series alone. Teak trees also suffered to a less extent in Dhaba, Ahiri Leased, and Sironcha Ranges. In the last range large numbers of *ain* (*Terminalia tomentosa*) and *dhaura* (*Anogeisus latifolia*) of all ages died off. A remarkable feature everywhere was the wholesale dying off of the pestilential Ironi creeper (*Zizyphus Oenoplia*) owing to the sinking of the water table.

Natural Regeneration.—Teak, *ain* (*Terminalia tomentosa*) and *tendu* (*Diospyros Melanozylon*) practically produced no seed. The *mukwa* flower crop was abundant and gave promise of good seed at the close of the year. Teak coppice was pretty good but was everywhere affected by the drought and in the six worked coupes of the Markhanda Felling Series nearly one half of the hitherto promising coppice died off.

Nursery Work—Steps were taken at the close of the year to establish a seed nursery at Allapilli.

Artificial regeneration.—Steps were taken at the close of the year to sow up with teak one acre of an area cleared of bamboos in compartment 35 Working Circle I Allapilli Range.

Thinnings and Cleanings.—The usual cutting back operations were carried out throughout 13,214 acres of the Division in the interests of teak.

Working Plans and Statistics. Yield tables.—The existing sample plots were measured up.

No new research work was undertaken in any of the divisions of the Northern Circle with the exception of two sample plots opened recently at Sarastal in the North-Mandla Division to ascertain :—

- (1) The rate of girth increment and volume increment of sal trees under light and heavy thinnings,
- (2) The kind of thinnings required,
- (3) The rate of growth of coppice,
- (4) The condition of natural regeneration if overhead canopy is opened,
- (5) Damage to coppice and seedlings by frost,

- (6) Damage by fire,
- (7) Whether suppression has been the cause of the trees remaining below 3' in girth all these years,
- (8) Whether natural regeneration is lacking on account of there being insufficient light on the ground.

The four sample plots of Jubbulpore-Narsinghpur mentioned in the last year's report were maintained. The rate of growth there appears to be slow.

In the Jubbulpore-Narsinghpur Division *tarkad Cassia auriculata* sowing was carried out on a small scale with unsatisfactory results.

Sal Regeneration.—Details of four sal regeneration plots laid out in May 1920 in South Raipur Division were given in last year's report. The regeneration has in each case improved but the progress is not yet sufficient to give any decisive results. Two new plots of $\frac{1}{2}$ acre each were laid out, Nos. V and VI with the object of testing the effect of burning on regeneration. Both plots were clear felled in May 1921 and plot No. V was burnt and VI unburnt. The result after the rains was a profuse growth of grass in both plots. In February and March attempts were again made to burn plot No. V but without success. The surrounding forest burnt easily early in March but this plot would not burn. The reason is by no means clear.

An experimental plot was opened in the Sarastal Range to see the result of light and heavy thinnings on sal crops.

A strip 20' wide and 103 yards long was cut in a sal area in the Sarastal Range to note the effect of light on regeneration.

Some teak coppice shoots were measured with a view to reduce the grazing closure of 10 years, the results are given below with an outline of the advantages of reducing the grazing closure from ten years to five years in the Dharwahi Range at least.

1. Grazing after 5 years helps to weed the forest and thus helps the growth of the coppice shoots and also gives seeds a chance of falling to the ground.

2. Fire protection can be reduced and proper protection would only be necessary for 5 coupes in each Felling Series. The remainder could be burnt in November and December.

3. More cattle could be admitted in many places and the revenue increased on grazing and expenditure on fire protection reduced.

4. Perhaps also stop many illicit grazing cases and thus give more time both to subordinates and D. R. O. for forestry; 80 teak coppice shoots were measured in 4 different coupes of 4 different Felling Series (coupes No. 20) (Felling Series II, III, IV and V).

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The average of each Felling Series was :—

Girths.				Age 3 years.
II.	III.	IV.	V.	
31 $\frac{1}{2}$ "	31 $\frac{1}{2}$ "	31"	31 $\frac{1}{2}$ "	Average 14 $\frac{1}{2}$ "
Height from 4' to 15'			...	Average 9'.

80 teak coppice shoots were measured as above in coupes No. 17 of Felling Series II to V and the results are as follows :—

Girth.				—
II.	III.	IV.	V.	
8 $\frac{1}{2}$ "	10 $\frac{1}{2}$ "	7 $\frac{1}{2}$ "	8 $\frac{1}{2}$ "	Average 8 $\frac{1}{2}$ " and 17' high.
Height from 13' to 28'				

45 teak coppice shoots in coupes No. 15 of Felling Series II and III gave the following results :—

8 $\frac{1}{2}$ "	12 $\frac{1}{2}$"	...	...	...	Average girth 10 $\frac{1}{2}$ ".
Height from 13' to 23'		...	...	...	Average height 18'.

From these data a 5 years old coppice shoot would be about 7" in girth and 15' high.

Coorg.

Killing Lantana with Sodium Arsenite.—Half a gallon of sodium arsenite, 25 per cent. solution, was handed over to the Somwarpet Range Officer and the same quantity to the Fraserpet Range Officer with instruction to dilute it to 10 per cent. solution and to treat dense lantana with the 10 per cent. solution (a) by cutting the stem near ground level and painting the cut surface and (b) by scraping the bark off the lantana stems in a ring near the base and painting the scraped surfaces.

The 25 per cent. solution was got from Messrs. Parry & Co., Madras, and cost Rs. 6 per gallon delivered in Coorg. The cost of 1 gallon of 10 per cent. solution therefore works out at Rs. 2-2-6 per gallon delivered in Coorg.

Plot A.—

The Somwarpet Range Officer used $\frac{1}{2}$ gallons of the 10 per cent. solution to treat as per (a) above and with this quantity was able to treat 8,850 sq. feet or about $\frac{1}{4}$ th acre. Therefore to treat 1 acre by this method costs $\frac{2}{1} \times \frac{5}{1} =$ Rs. 7-8-0. Labour employed for cutting lantana over 8,850 sq. feet, 7 men coolies at 6 annas and 5 women and boys at $\frac{1}{2}$ annas = Rs. 3-14-0. Therefore cost of

labour per acre is Rs. 18-12-0. Total cost of solution *plus* labour per acre = Rs. 26-4-0.

Plot B.—

The remaining $\frac{1}{3}$ gallon of the 10 per cent. solution was used to treat as per (b) above and with this quantity was able to treat 3,720 sq. ft. or about $\frac{1}{3}$ acre. Therefore to treat 1 acre by this method costs $\frac{1}{3} \times \frac{1}{3} =$ Rs. 18-0-0. Labour employed for scraping lantana over 3,720 sq. ft., 6 men coolies at 6 annas and 6 women and boys at 4 annas = Rs. 3-12-0, therefore cost of labour per acre is Rs. 45. Total cost of solution *plus* labour per acre = Rs. 63.

The cutting and painting of lantana in Plot A was done on 22nd, 23rd, and 25th October 1921 and the scraping and painting of lantana in Plot B on 25th and 26th October 1921.

The area dealt with in Somwarpet Range lies about $\frac{1}{2}$ mile to the east of Somwarpet village.

Fraserpet Range.—

Plot A. (Cutting lantana close to the ground and painting the cut surface). 7,569 sq. ft. of dense lantana were treated. Labour employed 5 men at 6 annas each and 1 boy at 4 annas = Rs. 2-2-0 (for $\frac{2}{11}$ acre). Cost of $\frac{1}{3}$ gallon 10 per cent. solution is (for $\frac{2}{11}$ acre = Rs. 1-8-0. Total (for $\frac{2}{11}$ acre) Rs. 3-10-0.

therefore cost of labour per acre	"	"	"	"	Rs. 11-11-0
" cost of solution per acre	"	"	"	"	" 8-4-0

Total cost per acre	"	"	"	"	Rs. 19-15-0
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Plot B.—

(Scraping off the bark in a ring near the base and painting the scraped surfaces). 7,812 sq. ft. were treated.

Labour employed 9 men at 6 annas each (for $\frac{2}{11}$ acre) Rs. 3-6-0

Cost of $\frac{1}{3}$ gallons 10 per cent. solution (for $\frac{2}{11}$ acre) " 1-8-0

Total (for $\frac{2}{11}$ acre)	Rs. 4-14-0
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therefore cost of labour per acre	"	"	"	"	Rs. 18-9-0
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Cost of $\frac{1}{3}$ gallons 10 per cent. solution per acre	"	"	"	"	" 8-4-0
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Total	Rs. 26-13-0
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The experiment was done in both plots A and B on 26th and 27th October 1921. On 20th November 1921 the Fraserpet Range Officer reports that of 100 stumps in plot A only 10 stumps were dead and the balance were sending up shoots from the base of the stump. In

Plot B on 20th November 1921 28 stumps were dead, the balance of 72 stumps were surviving.

The Somwarpet Range Officer reported that on 18th February 1922 shoots from cut stumps were coming up in Plot A. Seedlings also existed. In Plot B Root shoots had made an appearance and moreover the ringed lantana was not dead. A few seedlings were also noticed in this plot.

Mr. J. Prioris' Experiment on Spike in Sandal.—Mr. J. Prioris accompanied by the Deputy Conservator of Forests and Commissioner made some initial experiments into the effects of injecting a liquid antiseptic preparation, of his own compounding, with a hypodermic syringe into the stems of spiked sandal trees on 15th June 1922.

The trees were dealt with as follows :—

No. of tree.	Approximate girth.	Condition.	Nature of experiment.	Remarks Dated 18th June 1922.
1	8 inches	-- Spike confined to two or three young branches	Spiked branches removed; where branches had been cut off the cut surface smeared with a mixture of putty and an antiseptic.	To observe future development of spike. Forrester to report when spike reappears.
2	11 "	-- About 20 per cent spiked	Spiked branches not removed, a sixth of bark removed. Injected 8 divisions (of syringe) of the trial preparation on each side of the stem at 7' height. In all about 10 divisions went in. Bark replaced.	To observe whether injection affects health of tree and whether spike diminishes.
3	7 "	-- Had been pollarded, presumably spiked top having been removed. The regrowth branches are slightly spiked.	Again removed the whole surface by taking the top right off again.	Left as control tree for experiment No 5.
4	8 "	-- Far gone in spike	Wounds injected with No. 2.	
5	11 "	-- About 75 per cent spiked tree Spiked parts low down	Took top off as in No 2. Into centre of top of stem injected 13 divisions (of syringe). Covered cut top with putty.	
6	10 "	-- Slim tall tree 80 per cent spiked	Injected 13 divisions (of syringe) into each side of tree.	
7	15 "	-- Slightly spiked	Injected 13 divisions into each side.	
8	3 "	-- Healthy, but situated near spiked neighbours	Injected 10 divisions down.	
9	11 "	-- Completely spiked	Injected 3 doses of 13 divisions each.	With a view to see if tree remains free from disease
10	7 "	-- Healthy situated close to No 9.	Not injected	To be observed with reference to No 8 the presumption being that both 8 and 10 are likely to get spike owing to proximity to spiked neighbours. To see if No 8 gets off more lightly than No 10
11	12 "	-- Healthy tree situated about 10 yards to the Siddapur side of new Davanagere bridge, beside road	An attempt was made to inject the tree with disease. Cotton wool which had been kept about 3 hours in an injection under the bark of a diseased tree was placed similarly under the bark of the healthy tree.	

Madras.

The number of experimental plots under the control of this office was increased during the year from 42 to 62. Of the 62 plots, 27 are situated in the neighbourhood of the Chenai Nair Reserve, Dhoni, 10 in South Malabar and 25 in South Mangalore.

The chief problem under investigation is the regeneration of both evergreen and deciduous forests with evergreen species, the degree of shade under which seedlings can be best established and at what stage in their development further light should be admitted. Four evergreen species were experimented with in plots laid out in 1920 in the deciduous forests of the Dhoni valley. These have failed partly because too much shade was originally removed, as a result of which the first hot weather killed off large numbers of seedlings, and partly because the soil is so very light and porous that it will not retain sufficient moisture if exposed to give the seedlings a fair chance. An attempt to establish regeneration of *Hopca parviflora*, *Dichopsis elliptica*, *Mangifera indica* and *Artocarpus hirsuta* by sowing under varying degrees of evergreen shade in the Seppal valley was unsuccessful because the majority of the trees girdled in the upper and middle storey were not killed.

Although experiments in Dhoni and Seppal valleys have not as yet produced many positive results, a considerable amount of useful information on the regeneration of *Hopca* has been collected from South Canara and Coorg and by the end of another hot season there should be sufficient material at hand to justify the publication of a separate bulletin on this species.

In the Nilambur Teak Plantations *Hopca parviflora* and *Artocarpus hirsuta* were being experimented with as possible underwood for teak, but all work came to a standstill in August with the beginning of the Moplah rebellion, and has not yet been restarted.

Natural regeneration.—For investigation into the best method of uncovering natural seedlings 3 sets of plots have been laid out; but owing to the fact that many of the girdled trees did not die, no satisfactory results have yet been obtained.

Each set of plots was divided up into five sub-plots as follows:—

- (1) all weeds and shrubs of inferior species below 30' height cut out;
- (2) all weeds and shrubs cut out and trees forming the middle storey girdled;
- (3) all weeds and shrubs cut out and trees of inferior miscellaneous species forming the top storey girdled;
- (4) all weeds and shrubs cut and all but the valuable trees girdled;

(5) nothing done by way of weeding or girdling.

To discover what kind of opening has benefited the growth, results have to be observed after at least one or two growing seasons. As a result of similar uncovering carried out in Coorg, a marked increase in height growth was obtained.

With a view to discovering the effect of growth while young of some of the more important natural seedlings of evergreen species when they are fully exposed to sun in an evergreen type of forest one plot of 100 square yards was laid out in the Seppal valley, in May 1920, and the whole shade was removed in it and the seedlings were enumerated and staked. The age of the seedlings at the time of the experiment was believed to be 3 to 5 years, or more.

The following were the results noticed in December 1921 :—

	Average ht. on 29th August 1921.	Average ht. on 31d Decem- ber 1921.	Increase.
<i>Calophyllum tomentosum</i> ...	30.08"	31.2"	.12"
<i>Mesua ferrea</i> ...	28.35"	29.62"	1.27"
<i>Diosopsis elliptica</i> ...	18.34"	19.44"	1.10"
<i>Cullenia excelsa</i> ...	18.18"	19.42"	1.24"

In all the above cases of uncovering the letting in of light was sudden. Further experiments have to be made to see the effect of admitting more and more light in each growing season in one and the same plot so that the plot would be subjected to direct sunlight at the end of 4 or 5 years.

Seeds.—Experiments were carried out to ascertain the best method of collecting seed. In the case of *Artocarpus hirsuta* it was found that seeds extracted from perishing fruits dropped under mature trees and sown three days after collection germinated to the extent of 100 per cent. in one case and 88 per cent. in another, while of seeds of the same age but plucked off direct from branches of trees 78 per cent. have germinated. In the case of *Hopea parviflora* no material difference was noticed between seeds directly plucked from branches and those dropped on the ground, but it may be taken that collection from the ground is preferable.

As regards treatment of seeds the following conclusions were come to (1) removal of pericarp (*Artocarpus hirsuta*) had no effect on germination, (2) soaking did not appear to favour germination, (3) removal of wings (*Hopea parviflora*) did not affect germination (4) seeds kept in mud pot with mouth hermetically closed and buried under ground for 35 to 50 days have germinated 5 per cent. (5) boiled and soaked seeds of *Terminalia tomentosa* give a large percentage of success (this experiment will be repeated).

Experiments were carried out to ascertain if possible the difference if any between the germinations of seed collected from different localities and also of seeds collected from different sizes or ages of trees. Certain results were obtained but to draw definite conclusions it requires further investigation to see if similar results are obtained in respect of seeds collected from different localities but from trees of the same size.

As the result of one experiment with *Artocarpus hirsuta* it was found that seeds collected from large trees germinate better than those collected from small trees.

Best conditions required for germination.—From the experiments so far made it appears that no special conditions are necessary to effect germination excepting the fact that the seeds should be fresh and should be from mature trees. But it may be noted that the percentage of germination of seeds sown in the open was always higher than those of seeds sown under shade.

The statement appended below shows the minimum time taken for each species of seed to germinate.

<i>Artocarpus hirsuta</i>	x	o	e	u	o	24 days.
<i>Gmelina arborea</i>	x	o	e	u	o	12 days.
<i>Vateria indica</i>	x	o	e	u	o	1½ months.
<i>Hopea parviflora</i>	x	o	e	u	o	11 days.
<i>Hirdwickia pinnata</i>	.	.	.	.	.	2½ months.
<i>Terminalia tomentosa</i>	.	.	.	.	.	15 days.
<i>Dichopsis elliptica</i>	.	x	.	x	x	2½ months.
<i>Xylia xylocarpa</i>	.	.	.	.	.	10 days.
<i>Balanocarpus utilis</i>	.	.	.	.	.	9 days.

From the experiments carried out to see how long seeds retain their power of germination under ordinary conditions it has been recorded that seeds of—

<i>Xylia xylocarpa</i>	keep vitality up to	.	.	.	15 days.
<i>Gmelina arborea</i>	do.	x	x	x	30 days.
<i>Artocarpus hirsuta</i>	do.	.	.	.	7 days.
<i>Terminalia paniculata</i>	do.	.	.	.	5½ months.
<i>Hopea parviflora</i>	do.	.	.	.	7 days.
<i>Hirdwickia pinnata</i>	do.	.	.	.	15 days.
<i>Terminalia tomentosa</i>	do.	.	.	.	3 months.
<i>Lagerstroemia Flos Reginae</i>	do.	.	.	.	210 days.
<i>Dischostia javanica</i>	do.	.	.	.	28 days.
<i>Bombax malabaricum</i>	do.	.	.	.	86 days.
<i>Balanocarpus utilis</i>	do.	.	.	.	11 days.
<i>Adina cardifolia</i>	do.	.	.	.	65 days.

As regards soil preparation no special conditions seem necessary to effect germination.

It might also be noted that the results of experiments show that seeds sown and protected from sun by a brushwood covering gave a larger percentage in all the cases.

Nursery Work was carried out in the year under report which started with 5 nurseries, one in Palghat Division, one in South Canara, and 3 in South Malabar Divisions. Two more were laid out during the early part of the year, one at Mundakadavu in South Malabar, the other in Seppal valley of Palghat Division. The total cost of maintenance of these nurseries in the year amounted to Rs. 657-8-0.

Artificial regeneration.—(a) Experiments were carried out to discover if *Hopsea* could be raised in a pure crop in a deciduous type of forest, 4 plots being laid out at Dhoni.

Plot I.—Was completely in the open. Seeds sown in May and June 1921.

Plot II.—Seeds sown in May and June 1921 under shade of the existing trees.

Plot III.—Seeds sown under light shade such as that afforded by the middle storey of an open mixed deciduous forest.

Plot IV.—Seeds sown under light shade formed by the top storey of deciduous species.

(b) To discover the degree of shade necessary to establish regeneration, by artificial means, of the more valuable evergreen species in an evergreen type of forest 5 contiguous plots were laid out in June 1921 in Seppal valley and seeds of the following species dibbled in, *Artocarpus hirsuta*, *Mangifera indica*, *Dichopsis elliptica*.

To come to any definite conclusion on the effect of various degrees of light let in, the growth requires observation for at least 2 hot weathers.

(c) To discover if pure crops of the following species could be raised by dibbling or planting 6 plots have been laid out at Dhoni and the growth in the several cases is noted below.

Spec. no.	Nature of plot.	SEEDS SOWN IN MAY 1921.			SEEDLINGS IN JANUARY 1922.		
		Weeded.	Unweeded.	Weeded.	Ht.	Unweeded	Ht.
<i>Valeria indica</i>	Flat open	463	56	1920 6	1'	1	11"
				1021 4	0"	58	6"
<i>Mangifera indica</i>	Dibbled under a light overhead shade of standing deciduous trees.	454	357	1020 59	2½"	5	—
				1021 120	0"	74	9' 1"



Июль парижера, from broadcast sowing of 1910 exposed to light in 1920, by removing middle storey, shrubs and weeds.

Species.	Nature of plot.	SEEDS SOWN IN MAY 1921.			SURVIVALS IN JANUARY 1922.		
		Wooded.	Unwooded.	Wooded.	Ht.	Unwooded.	Ht.
<i>Bombax malabaricum.</i>	Completely open ...	187	235	1920 19	8½'	65	5' 1"
<i>Bombax malabaricum.</i>	Dibbled under a light overhead shade of standing trees.	389	193	1920 104	1' 4"	31	3' 10'
<i>Gmelina arborea</i>	Fully exposed to sun.	728	536	1920 17 1921 86	5' 1'	83 2	7' 8" 1'
<i>Terminalia paniculata.</i>	Dibbled under light shade.	672	..	1921 21	4"	...	...

NOTE.—All the above plots were re-cown in May 1921 when the sowings of 1920 failed.

(d) Three plots have been laid out in the compound of the Forest Rest house at Parappa to discover the most suitable age at which and the extent to which natural seedlings of *Ilopec* can successfully be transplanted and also to see what the effect will be of pruning the root before transplanting seedlings. One to 5 years were planted, some with roots intact and an equal number with roots pruned. The following are the results recorded.

Plot No.	Date of planting.	No. and age of seedling.	SURVIVALS IN FEBRUARY 1922.			
			Of those planted with roots intact.		Of those with roots pruned.	
			No.	Ht.	No.	Ht.
I.	4-7-20 ...	25 1 year ...	10	7½"	13	8½"
	" ...	25 2 years ...	17	12"	19	11"
	5-7-20 ...	25 3 " ...	17	14"	10	11"
	19-7-20 ...	25 4 " ...	14	17½"	14	17½"
II.	7-8-20 ...	100 1 year ...	16	9½"	64	9½"
	" ...	100 2 years ..	14	7½"	23	8"
	8-8-20 ...	100 3 " ...	48	11½"	50	11"
	" ...	100 4 " ...	45	11½"	60	12½"
	" ...	100 5 " ...	70	11"	65	12½"
III.	9-11-20 ...	100 1 year ...	"	6"	25	6"
	10-11-20 ...	100 2 years ...	8	7"	4	7"
	" ...	100 3 " ...	20	6½"	8	7"
	" ...	100 4 " ...	20	9"	11	7"

(e) The last experimental plot laid out was to ascertain the coppicing power of some of the more valuable natural seedlings of evergreen species if they are cut back in the event of their being damaged during the felling and removal of the overwood in the general scheme of exploitation in the Chenat Nair evergreen forest.

Species.		No. of seedlings coppiced.		Coppice shoots counted on.
			24-8-21.	14-12-21.
<i>Dischopsia elliptica</i> ...	..	30	1	1
<i>Oullenia exoclea</i> ...	...	143	5	40
<i>Mesua ferrea</i> ...	...	10	7	13
<i>Calophyllum tomentosum</i> ..	..	8	nil	nil
Miscellaneous ...	...	311	41	111
Total	...	510	54	165

It is still too soon to draw any definite conclusion.

(f) As suggested by the Imperial Silviculturist in his inspection notes of May 1921, one plot half an acre in extent has been laid out in the Seppal valley of Chenat Nair R. F. to discover if evergreen species can be grown by direct sowing in the open on prepared soil.

The plot will be dibbled in May 1922.

Comparison between direct sowing and transplanting.—No experiment has yet been made in this direction. But all the experiments made in transplanting were with reference to :—

“What species can bear transplanting” and the following are the results carried out.

Name of species.	Age of seedlings transplanted.	Percentage of success.
<i>Hardwickia pinnata</i> ...	3 months.	54.05
<i>Hopea parviflora</i> ...	5 "	95.25
<i>Xylia xylocarpa</i> ...	3 "	18.33
<i>Vateria indica</i> ...	2½ "	75
<i>Terminalia tomentosa</i> ...	3 months and 3 weeks.	80.55
<i>Terminalia paniculata</i> ...	5 months.	67.50
<i>Artocarpus hirsuta</i> ...	1 year.	80
<i>Gmelina arborescens</i> ...	7 months.	90

The above results go to show that in preference to dibbling of seeds transplanting could be resorted to, with every prospect of success. But the best age for transplanting remains to be ascertained.

Stump Planting.—At the instance of the Conservator of Forests, VI Circle, planting stumps of *Gmelina arborea* and *Bombax malabaricum* was attempted. Seedlings one year old (above 3' high), were cut leaving 3" root and 3" stem of each.

Of 20 stumps of *Gmelina arborea* planted on 2nd August 1921, 13 were found established and of 21 *Bombax* 20 had survived at the end of December 1921.

Working Plans and Statistics.

Yield Tables.—A number of plots are being maintained. In South Mangalore the periodical diameter and height increment of *Hopea* trees of known age, grown in an even-aged mixed forest condition, on a second class soil are being recorded in the Parappa teak plantations. An average diameter increment of .27" per annum was recorded for the five years ending 1916 and of .32" for the five years ending 1921.

Three plots were laid out in Pillarkhan in 1921 for comparative research with regard to volume increment and general development in height, form factor, diameter, etc., of *Hopea parviflora* grown in a pure crop in second class soil. The next measurements of these plots are due in 1927.

Four plots were laid down by the Central Institute in 1916-17 at Mundanthorai to ascertain the volume increment and development of teak coppice with standards. These were transferred to Madras in 1919-20.

The remeasurements due in January 1922 in the plots in South Malabar could not be carried out owing to the Moplah disturbances.

Punjab.

As mentioned in the previous year research work in the Kulu Division is being continued to ascertain the best method of regenerating the spruce and silver fir woods, but owing to the shortage of labour and the unsaleability of the output exploited from certain of the forests in which research is being carried out the work was retarded. A paper on this subject was written by Mr. H. L. Wright, Deputy Conservator of Forests, and Lala Parma Nand, Extra Assistant Conservator of Forests and read at the Punjab Forest Conference in February 1922. Similar research has been started in the Bashahr Division during the year.

In the Afforestation Division research work has been started in connection with the afforestation of the Pabbi Reserve.

The Khairmuft Olive Plantation was placed under the charge of a trained Supervisor towards the end of the year, but the success of the plantation seems rather doubtful as the fruit yield of the crop suffers badly in years when there is a shortage of rains. If the quantity of fruit produced during next year is not satisfactory the question of abandoning the experiment will have to be considered.

The propagation of lac which was started in the Hoshiarpur Division last year has made satisfactory progress during this year, although the larvae were attacked by a species of large black ant in August 1921. More than 1,100 trees have been definitely infected with lac and further extension is being made. The sale of the season's crop was frustrated by the local non-co-operators, who prevented the buyers from bidding.

The experiments in regard to the correct rotation for cutting over bamboos were continued in the Kangra and Hoshiarpur Divisions and final results will be available next year.

Experimental sowings of eucalyptus species were tried in Kangra and Simla Divisions but failed. The experiment is also being tried in the Kot Lakhpat Plantation, but no definite result has yet been attained.

Fomes annosus, the fungus which attacks young deodar, continued to be under observation in the Kulu and Bashahr Divisions, but no satisfactory remedy against its attacks has yet been found.

The experimental rearing of Belladonna was continued in the Nagketo Reserved Forest, Simla Division, as reported last year, but no definite result has yet been arrived at.

Food and fodder crops are being raised experimentally in a number of deodar and *kail* forests in order to ascertain whether this affords a prompt or economical means of regeneration. In some patches of forest destroyed in last year's fires wheat crops were recently seen to be very promising, in others buckwheat and potatoes are being extensively grown. Figures at present available show that one crop will not as a rule pay for the labour of clearing the ground of burnt saplings.

UNITED PROVINCES.

Experimental Silviculture.

General.—Constant endeavours have been made to improve the standard of all silvicultural operations and some success has been obtained. In the best managed divisions there is a distinct improvement in all classes of markings but much remains to be done before this aspect of silviculture can be considered satisfactory. The

correct technique of regeneration markings, the proper treatment of regeneration areas, efficient thinnings and cleanings and the best methods of artificial reproduction have been matters to which the Conservator of Forests, Working Plans Circle, has repeatedly drawn attention and on which his advice is frequently sought by divisional officers. Notes on items of interest have been circulated and endeavours have been made to keep the Executive Staff informed of the progress of knowledge and to stimulate the interest of all in scientific forestry.

The work carried out in the Silviculture division has followed as closely as possible the printed programme of research for the Working Plans and Silvicultural Research Circle. For the first 6 months of the year, the shortage of staff in the Province necessitated the Silviculturist's holding charge of the Haldwani division in addition, but from the beginning of the working season, for almost the first time since the creation of the post, the Silviculturist was left untrammelled with other duties and was free to devote all his energies to pure Research. Thereby the programme of research work carried out received a great stimulus, and much useful and important work was taken in hand.

Natural Regeneration.—(1) (Sal). The natural regeneration of the sal remains by far the most important silvicultural problem of the province. Much has been learnt on the subject as the result of the researches of several officers and it can be said with some confidence that the problem is well on the way towards solution.

The series of important experiments in Lakhmandi C4 referred to in last year's report were continued and extended. It must again be emphasised that this research is directed towards a study of the conditions of development of a seedling crop already on the ground, and not a study of requirements for getting such a crop. The results obtained during the year may be briefly summarised.

A.—In the areas clear felled and heavily felled.

(1) The very heavy felling and intensive conversion results in considerable trampling and smashing of the young sal plants, and enormous accumulations of slash and debris. When this is burnt off, a fierce fire results, and after the fire the existing plants of all sorts are almost entirely cut back, flush with the ground, and are invisible. The ground is left bare, with a fertile deposit of ash.

(2) This trampling and burning was followed by the fiercest and driest hot weather on record. Despite this, the sal plants sent up healthy shoots in large numbers, which successfully persisted until the rains broke. This proves that there is no fear of drought killing the young plants on these good quality Bhabar soils.

(3) Throughout the rains and subsequent cold weather, the young sal plants preserved a very healthy appearance and showed no indications of wanting to die back (in marked contrast to the plants in the adjoining unfelled areas).

(4) At the beginning of the following hot weather a high per cent. of the young plants commenced new growth, putting out new shoots from the top of the previous years growth, and *not from the base or root stock*. In most cases the 12 months' growth equalled the growth of the previous 7 years !

(5) Weed growth and grass came up very vigorously in the felled areas, and in November appeared to be smothering the young plants, but by April it was evident that the young sal much prefers the conditions of open growth, with the inevitable severer competition of weeds, to the closed canopy with a layer of decaying sal leaves.

(6) The percentage of survival in the heavily felled and burnt areas amounted to 65 per cent.

In the adjoining unfelled and unburnt areas the percentage of survival was 49 per cent.

B.—In the unfelled and unburnt areas.

The condition of the young sal plants throughout the year was extremely poor. A large per cent. disappeared altogether, and the remainder showed very little upward growth.

These results conclusively show that even the most drastic treatment possible is better for the young sal plants than attempting to nurse them up under a heavy shelterwood, without removing the mat of dead sal leaves, which in the rains form an acid airless blanket, and have a most deleterious effect on the young plants.

It now remains to be seen to what extent the young sal plants will succeed in struggling up through the more vigorous weed growth, and how many years it will take. It is believed that in the heavily felled areas, the young plants (9" to 2' high at the time of felling), will be firmly established and free of the grass and weeds in from 6 to 8 years of the felling, without any further assistance.

During the year the series of experimental 25 acre plots was extended by the addition of 2 plots with strip fellings as advocated by Mr. Hole and one plot with shelterwood fellings, the idea being to compare the results between the two methods. Also the surrounding forest (except for a 25 acre control plot) was burnt early in April without felling, to remove the layer of dry sal leaves, to see what the effect of mere burning without felling will be.

In the course of a few years, it is hoped to obtain conclusive results from this series of large scale experiments which may have an important influence on the future management of the large areas (400,000 to 500,000 acres) of Bhabar, Plains and Tarai forests of the United Provinces. Similar large scale experiments of 25 acres were also commenced during the year in South Kheri and North Kheri, in different types of sal forests. The results will be noted next year.

Several divisional officers contributed to this investigation. In Dehra Dun Mr. Mathura Prasad Bhola continued his experiments at Lachiwala designed to show the simplicity of regenerating a sal forest containing a more or less profuse advance growth under circumstances which do not admit of a system of simple coppice as in Gorakhpur. The system resolves itself into—

- (1) Selecting the seed trees 20—25 to the acre.
- (2) Cutting everything else clean.
- (3) Burning what remains of the slash after more or less complete conversion.
- (4) Regenerating by coppice wherever available and elsewhere by seed.

Most excellent results have been obtained with the coppice both in the shelterwood and clear felling but the latter method will not be persisted in as the frost hazard is too great. Mr. Bhola writes as follows :—

Lachiwala plot.—(1) In the months of May and June 1921 almost all the new shoots were browsed by deer but they soon recovered and immediately made up the loss. No damage from frost was seen in either of the plots, only a few plants were slightly effected.

(2) The development of coppice shoots in both the plots was good. The average height growth in the clear felled and shelter wood plots was 79 and 103 inches respectively.

(3) No natural reproduction of 1921 was noticeable in the shelterwood area as the rains were late, though sal seed was abundant.

(4) The weed growth of *karop*, *Clerodendron infortunatum*, *karaunda*, *Carissa spinarum* and *munj* grass was noticeable in both the areas but did not appear to be doing any damage at present.

(5) Half of each of these plots comprising an area of about 10 acres was thinned in the month of April 1922 at a cost of Rs. 12.

Timli Range.—(1) No damage from frost, some browsing by deer was seen in the clear felled area and a little in the shelterwood plot.

(2) The growth of coppice shoots in the clear felled area is more vigorous than in the other.

(3) Seedling crop of 1921 is very scanty in both the plots.

(4) The weed growth, especially that of *maljahan*, *Bauhinia Vahlia*, was enormous in the clear felled area while *Clerodendron infortunatum* appeared in the shelterwood plot. This weed growth does not appear to be doing any damage at present.

Two new shelterwood sample plots of 10 acres each were laid out in the Lachiwala and Timli Ranges close to the old ones, all material except the shelterwood was felled and removed and the areas burnt in April 1922. The results will appear in the next year's report.

Experiments with fire as a means of stimulating the reproduction of sal and reducing heavy evergreen undergrowth were carried out in Lansdowne, North Kheri, Bahraich and Gonda divisions and burning has invariably given good results. A complete carpet of sal seedlings was obtained in this way in C 41b of North Kheri whereas in the ordinary forest there was little or no reproduction.

Our above experiments have therefore shown us the way to obtain germination and the Haldwani ones the way to make these seedlings grow, so that we are well on the way to complete success. The Conservator has devoted considerable attention to the proper treatment of sal under coppice with standards and management has been much improved in revised working plans. The simple coppice system of Gorakhpur continues to give excellent results. A modification of the routine by substituting burning for unremunerative cleanings was suggested by the Conservator, Working Plans Circle, after his rains tour and at the next revision of the plan the rotation will be lengthened in accordance with the results exhibited by the new yield tables for sal.

(2) *Miscellaneous Species*.—Several important and interesting results have been established and will be noted on by species.

(a) *Haldu* (*Adina cordifolia*) (i) Following the fierce burning of the slash and felling debris in Lakhmanmandi C4, mentioned above, a magnificent and almost complete crop of natural *haldu* seedlings appeared in the rains wherever a smouldering log or a half burnt stem had effectively baked the soil, killed the weeds, and left a thick deposit of ash. Their development was remarkably good, and although many disappeared in the cold weather and all were grazed back by deer—sufficient seedlings have survived, and will it is believed, now continue to survive, to form a complete crop. (However, as this is primarily a sal regeneration area, the *haldu* plants will be kept back if found to interfere with sal plants). In the adjoining unburnt areas, not a single *haldu* seedling came up. The method of obtaining successful natural regeneration at a minimum of cost and trouble is now fairly evident for rich moist soils overlying the Bhabar gravels. The future development of these *haldu* seedlings will be carefully noted:

(ii) The 50 acre plot of natural *haldu* regeneration (mixed with khair, sissoo and *Holoptelea* regeneration) in the Nandhaur old river bed which was fenced last year by the Special Forest Officer, Tarai and Bhabar Estates, was carefully noted, and the following points established:

- (1) The *haldu* plants showed no material growth during the year, but remained in leaf to late in November, long after the plants in the surrounding tract open to grazing had become leafless.
- (2) The plants remained leafless and inconspicuous until April when new leaves were again formed, and the plants showed indications of shooting up.

- (3) The closure to grazing greatly improved the condition of the sissoo plants, which shot up vigorously during the year, and were most flourishing.
- (4) Generally speaking it is evident that closure to grazing had a most beneficent result on the experimental area, and in 6 or 8 years it appears certain that a well established crop of young trees will be established. It proves that it is only heavy grazing which prevents the natural afforestation of those bare old river beds.

(iii) Very similar results have been noted with natural *haldu* seedlings in the areas closed to grazing of the Haldwani lantana plantations (referred to below), which will in time contain a fair percentage of natural *haldu* trees. The plants are still affected by the grazing of Nilgai, but are gradually growing into safety.

It may be said with confidence that the problem of *haldu* regeneration, which for so many years was a perplexing conundrum to Forest Officers, is rapidly approaching satisfactory solution, and the secret of success appears to lie in careful attention to the following factors :—

1. The seed and the young seedlings must be protected from flooding and from being washed away.
2. The soil must be clean, loose, and preferably fairly porous.
3. Complete freedom from weeds.
4. Subsequent protection from grazing.

With these 4 factors assured, success is almost certain.

As regards the hill conifers, methods of natural regeneration of the *chir*, *kail* and deodar are well-known. The natural regeneration of *ban* oak under a shelterwood is being undertaken in Ranikhet.

Artificial regeneration.—**SAL** :—The feature of the year is the successful solution of the problem of the artificial regeneration of sal in the Gorakhpur coppice coupes.

These experiments have a history dating back to 1914, and it is mostly a history of failure in which much knowledge has been gained. The complete history of the Ramgarh-Tilkonia experiments has been written by Mr. Wood and published in the "Indian Forester" for February 1922 at pages 53 to 77 and this contains all the information up to August 1921. Since that time what has to be considered is the effect of one growing season which has been a favourable one, and it can be said that in all cases those plants which were not doing well are still not doing well, and that those which were doing well have continued to show every promise. At the same time the matter cannot be dismissed in this report at this point.

LIFRIL

The clear felling system was adopted in Gorakhpur with confidence leavened with misgiving. It was known that when abundance of young poles existed, the response of the shoots on the clearfelled areas was extraordinary. At the same time the greatest optimist at that time could not say for certain what would happen where young poles did not exist. No one knew how to regenerate sal with certainty, and no true Forester could contemplate with equanimity the prospect of creating blanks, especially as there were not inconsiderable areas where young poles did not exist.

The following methods were successively tried in order to induce regeneration.

Leaving seed bearers on the clear fellings resulted in a complete failure and was soon given up.

Sowing under the old crop in prepared patches and wounding the soil and sowing. Failed.

Transplanting root and shoot cuttings of sal. A complete and final failure after prolonged careful trial.

Digging and sowing under the old canopy opened out. Has failed.

Digging and preparing the land and sowing and tending the sal in the open on the clear fellings. This has been a success.

This work was done in coupe 2, Tilkonja, under forest conditions. An unfenced area exposed to illicit grazing and fire. It has stood the test of a bad rains, a frosty cold weather for these parts, a bad hot weather and a fire. The plants have remained healthy and sound for 2 years and in the year under report they have come through and are now thoroughly established.

It can now be said therefore that when clear felling is adopted in this division that, barring causes over which we have no control, artificial regeneration of blanks created by clear felling can be successfully carried out with a confident expectation of success, and it is hardly possible for any one not in charge of the division to realise the relief which this knowledge gives. Costs are still high and the work has not yet reached the stage of definite routine, but that is a matter of detail which time will set right. The key discovery has been made and since the close of the period under report it has been possible to commence preparations for the cultivation of sal with field crops which should lead to the artificial regeneration of 80 acres at a cost amounting to practically nil. If that work succeeds, then all difficulties, both silvicultural and financial, will have been removed and our regeneration operations will not appear on the debit side of our budget at all.

It is proper that the report, which at last records success in this matter should contain the name of Pandit Ram Bhattan, a vernacular Forest Ranger who has been in executive charge of the work from

the beginning and whose care and diligence, as well as his silvicultural sense has been beyond all praise.

Two small scale experiments were made in Dolpokhra plantation, (an area subject to severe frost) to examine the possibilities of artificial regeneration of sal, (a) in the open, (b) under a shelterwood of sissoo. Results will be noted next year.

Experiments in artificial sal regeneration in the dry soils of Jaspur Range are under the Divisional Forest Officer, Ramnagar, but nothing can be done till a good seed year arrives.

Miscellaneous Species.—The sowing and planting of miscellaneous species was continued in the experimental garden at Haldwani; in the Dolpokhra plantation and on an extensive scale by Mr. Murphy, Special Forest Officer, Tarai and Bhabar Government Estates. This officer has obtained very considerable success and much of the knowledge available is due to his efforts. *Haldu*. Successful results have been obtained in the Tarai plantations at Lalkua with transplanting small natural *haldu* seedling (2½ months old) in September. A good percentage survived the cold weather and started new growth in March and April.

Sain (Terminalia tomentosa).—The general bad quality and shortage of seed last year prevented very much being done with this species, but the experiments carried out in S. Kheri, Horai, Dolpokhra, etc., suggest:—

1. That a moist rich loam or fairly stiff clay loam is desirable for this species, which fails on gravelly or loose sandy soils.

2. That it is intensely liable to damage by grazing of deer, hares, cattle, etc.

3. That on favourable soils, and if adequately protected from grazing, its regeneration is a comparatively simple matter, and it grows up quickly without dying back. *Holoptelea integrifolia*. All experiments with artificial regeneration of this species in the open have failed, and it appears essentially to be a species to be regenerated under a shelterwood of sissoo on loose sandy or gravelly soil.

Sissoo (Dalbergia Sissoo).—Very considerable success has been obtained with this species over a wide range of conditions, and it appears pre-eminently the chief species for afforestation on dry gravelly or sandy soils or loose fertile loams but not on stiff loams and clays. Its natural regeneration appears largely confined to new river beds and landslips.

A wide range of experiments with other important Bhabar species (amongst which should be mentioned *Acacia Catechu*, *Anogeissus latifolia*, *Bambusa malabaricum*, *Lagerstroemia parviflora*, *Gmelina arborea*, bamboos, etc.), have also been started, and results will be noted as they become available.

Afforestation.—The work in the Afforestation Division was continued and the plantations were extended by 2,000 acres. *Hardwickia binata*, *Albizia procera*, and *Acacia Catechu* were experimented with on a considerable scale. Babul would be an excellent species but for frost which causes great losses in all low lying areas. An experiment in connection with local races of babul seed is in hand. A scheme for the afforestation of the North Kheri phantas is under preparation but it is doubtful whether the expenditure can be justified at the present time.

The attempts to grow sissoo as a shelter to the frost bitten sal shoots in the *chandars* of South Kheri and Pilibhit have not so far been attended with much success but this matter will be again taken up.

Thinnings and Cleanings.—These operations are prescribed in all new working plans both in high forest and coppice crops, the urgency of this work has been repeatedly pointed out and is at length being realised by the Executive Staff.

Silvicultural Systems.—The shelterwood system is now a standard system for the sal forests of the province wherever the locality and the growing stock justify this method of treatment. The essence of the system is as follows :—

- (1) Develop a good crop by constant thinning.
- (2) Obtain regeneration by burning.
- (3) Open the canopy somewhat heavily.
- (4) Cultivate the soil where this must be done to obtain seedling reproduction.
- (5) Cut back advance growth drastically.
- (6) Coppice to count as good as seedling reproduction.

A new system has been developed for the Nawadia forests of Pilibhit. A start is made with the ordinary coppice with standards, blanks in the coppice are filled up artificially, the standards are thinned out and finally removed within 10 years leaving the coppice to develop into high forest, where selection is retained; a yield by volume has been substituted for a yield by area and good silviculture insisted on. It has been definitely established that simple sal coppice is not a suitable silvicultural system where most damage is to be expected.

III.—Working Plans and Statistics.

The plans for the Dehra Dun, Saharanpur, Landsdowne, North Kheri, South Kheri and Pilibhit Divisions were under revision during the year. The plan for Chakrata Cantonment forests was finished and published and the preliminary report on the Gonda forests was prepared. All the above plans are on up to date lines and need not fear comparison with the plans of continental Europe. The position

as regards plans is now normal. Five to six important plans can be dealt with at one time and the organisation and supervision of the work enable plans to be prepared by officers too junior or inexperienced to be entrusted with this work under the old conditions, under which a man was sent to make a plan without any fixed policy having been settled as to the lines on which the work should be drawn up. The work in the Silviculture division is intimately bound up with the preparation of working plans, both as regards experimental forestry and statistical work. The working plans branch has now a complete knowledge of the forestry of the province and is in a position to keep the Executive staff in touch with the latest discoveries and developments and to give the best advice available on any subject. There can be no question that the creation of the Working Plans Circle has been of great benefit to the forestry of the United Provinces.

A large amount of work has been done during the year in the remeasurement of old sal plots and laying out of new plots. 30 old plots were remeasured, 20 new permanent plots laid out and measured, and 34 temporary plots were measured, totalling 84 plots. Simultaneously with the field work, the necessary calculations of the plots and measurements were made, involving much additional work (which should theoretically be done at the Forest Research Institute, Dehra Dun, but the authorities there indicated their shortage of staff rendered it quite impossible for them to do this work). The statistical staff (Pt. Bhiawani Datt, E.A.C., and Ranger Raghubans Swarup) deserve great credit for the hard work undertaken and successfully carried through.

This great mass of additional statistical data rendered it possible to commence the compilation of Volume and Yield Tables for the United Provinces sal forests, and during the 3 months of the year under report, the writer was chiefly engaged in the preliminary calculations. These were completed, and the Volume and Yield Tables were finished in May, after the close of the year under report, and during the coming year it is hoped to bring out an interesting and useful publication on the results.

It will not be out of place here to mention that the results of research on sal carried out during the last 10 years by the Research Officers at the Forest Research Institute, Dehra Dun, and in the province justify a practical revolution in the systems of management of the United Provinces sal forests of the Plains and Bhabar by—

(a) Enabling more scientific silvicultural system to take the place of the old "Selection with Improvement" method.

(b) By reducing the rotation for sal by roughly 25 per cent.

and it is claimed that the money value of this research will be represented, on a low and conservative estimate, by an increase of at least Rs. 10 lakhs *per annum* in the Provincial Forest Revenues.

Owing to the pressure of statistical work in connection with sal, very little attention could be paid to the statistics of miscellaneous species, but during the year the following sample plots were remeasured or laid out—

<i>Shisham</i>	..	..	..	..	8
<i>Semal</i>	..	..	..	..	1
<i>Jaman</i>	..	..	..	..	1

Regeneration experiments in the Improvement Working Circle, Ramnagar Division.

Owing to the pressure of other works no experiments were taken in hand this year under this head, but the experiments on *bakli*, *khair*, *sain*, etc., in hand in other areas are supplying useful information. It appears advisable to transfer the experiments under this head to the Gonda Division.

Yield tables and sample plots.—During the year a number of old sample plots in *chir* and oak were remeasured and a number of new plots laid out, *viz.*,

Chir—

Old plots remeasured	15
New plots laid out	12
Temporary plots	2

Oak—

Old plots remeasured	18
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Unfortunately several plots were severely damaged by the fires of 1921.

There are still too few plots of the larger diameter classes to take up the compilation of a yield table. Further plots will be laid out as opportunity occurs.

Various miscellaneous investigations are in hand. The experiment of cleaning undergrowth in *chir* pine woods to see the effect, if any, on the flow of resin was continued with the following results:—

Statement showing yield in Siuni Compartment 13, Experimental Area.

Month.	No. of Channels	CLEANED UP UNDERGROWTH.		UNCLEANED UP UNDERGROWTH.		REMARKS.
		Mds. Srs.	Per cent. Channels Mds.	Mds. Srs.	Per cent. Channels Mds.	
April	102	5 4	0.23	4 3	0.21	Not tapped from June owing to fire.
May	"	14 6	0.55	4 19	0.23	
Total	"	19 10	0.90	8 22	0.44	

The beneficial result of removing undergrowth on the yield of resin is again demonstrated. It should be noted in this connection that even if the flow of resin is not really affected the yield per acre is improved in practice and the cost of tapping and collection are likely to be reduced by clearing thick undergrowth, which is a great hindrance to resin tapping operations.

A severe attack of *Peridermium complanatum* on *chir* was noticed in the hot weather probably as the result of last year's fires. A paper on *P. corticola* was published by Mr. Champion in the "Indian Forester" for April and May 1922 and a paper on twist in *chir* by the same author is awaited. Experiments with "Atlas A" and sodium arsenite for the poisoning of shrubs and climbers were continued with varying results.

CHAPTER III.

BOTANY.

Central Institute.

Shortage of staff and equipment caused by financial stringency have materially restricted research work during the year but some progress has been made with the items noted below.

Occology of Sal.—A summary of most of the experimental work carried out up to date on the factors influencing the development of sal seedlings was published during the year (*Indian Forest Records*, Volume VIII, Part II, 1921). Based on these results an experimental trial with a group-cum-strip system of regeneration was suggested for certain types of sal forest. This system possessed two features which rendered it troublesome to work on a large scale, viz. :—

- (1) the prescription that only alternate strips should be regenerated, the regeneration of the intervening strips not being undertaken until the second half of the rotation.
- (2) the prescription regarding a chess-board arrangement of patch fellings which are gradually extended in the form of strips.

The object of (1) was to insure as complete security as possible from drought and frost damage, by the provision of adequate side-shade both from the east and west, and of (2) to diminish damage by heavy weed growth. An inspection during the year of one of the Dehra experimental areas, 180 feet in diameter, which was clear felled in 1915 and sown with sal in patches revealed the fact that the seedling growth here now was much more satisfactory than appeared probable at first. The seedlings here suffered considerably from drought during the first few years but now, after 5½ years, several have become thoroughly established with a height growth attaining 5-8 feet. This, it is believed, justifies the conclusion that

the more convenient system of continuous strip fellings (which will always insure side-shade from at least one direction) can be safely adopted instead of that of alternate strips. In the second place, it is probable that, as suggested by Mr. C. G. Trevor, weed growth can be sufficiently controlled by varying the width of the strips instead of by a chess-board arrangement of felling. With the co-operation of local officers in the United Provinces large scale tests of strip fellings on these modified lines have been carried out during the year in the Dehra Dun and Haldwani Divisions.

The only factor which at present appears likely to militate against the success of the system is damage by rats. In the Dehra Dun experiments these animals have been responsible for very heavy mortality among the young sal plants by biting through the sappy tap roots of vigorous seedlings and saplings. As mentioned in last year's report, however, it is believed that this damage will be relatively unimportant when work is carried out on a larger scale. During the year, also, it was noticed that rat damage appears to be invariably worst where there is a heavy growth of grass especially of *Imperata* and large tufted species of *Saccharum*. The rats appear to be primarily attracted by the succulent rhizomes of the grasses on which they feed and incidentally they bite through the succulent sal roots which they come across in their burrowings in the grass. It is believed that grass growth and consequently rat damage can be adequately controlled by keeping the strips narrow, by allowing all good coppice growth to develop on the strips and form a part of the future crop and by sowing sal thickly and weeding during the early years, so that the seedlings may quickly form a close canopy.

The advantages of this strip system over the ordinary seeding felling method at present appear to be that it provides more suitable conditions of soil moisture for seedling growth, greater security against weeds, greater concentration and better control of artificial sowings and cultural work. It also avoids the damage to the young growth occasioned in seeding-felling areas by the felling and export of the mother trees. At the same time the strips get the benefit of most of the natural seed produced by the trees on the edges of the cleared strips. Whatever success is eventually obtained with the strip system will be mainly due to Mr. C. G. Trevor, Conservator of Working Plans in the United Provinces, to Mr. E. A. Smythies, Silviculturist, and to Messrs. H. G. Champion and M. P. Bhola, Divisional Forest Officers of Haldwani and Dehra Dun respectively, who have heartily co-operated in the work of testing this system experimentally.

Systematic.—A matter the importance of which has become increasingly evident during the year is that of disseminating widely through all ranks of the Department a good practical knowledge of our forest species. It is frequently not realized how much economic development is hindered by the insufficient knowledge of species

on the part of local officers, which makes it difficult to collect information regarding the local distribution and yield of commercial products and to obtain samples of them for research purposes. It is believed that two causes are chiefly responsible for this, *viz.*—

- (1) a tendency which has been somewhat prevalent in the past to think that a forest officer who studies and tries to know well the plants in his forest is gradually becoming "only a botanist", and is therefore decreasing in value as a practical forest officer ;
- (2) the fact that the classical detailed floras now available in India, indispensable though these undoubtedly are, do not sufficiently facilitate the successful identification of species by the average forest officer.

As regards the first point, the idea appears to be due to a misunderstanding, on the one hand, regarding the lines of work which fall within the legitimate scope of the science of botany and on the other hand as to the kind of botany which an efficient forest officer ought to know. The decision as to the correct botanical name for any particular species or other group depends upon herbarium work and a study of the herbarium specimens, plates and original descriptions on which those groups are based and which are the authority for the various published specific and varietal names. Forest Officers, as a rule, have neither the time nor the opportunity for doing much work of this kind which should be done by the expert herbarium botanist. On the other hand, what is usually called field work which comprises a study of the living plants in the forest, of the characters which enable us to recognize them in the forest at different seasons of the year and of the range of variation which these exhibit forms a necessary part of forest botany and, to a more or less considerable extent, is an essential part of the equipment of every efficient forest officer in India. A great deal could be done by those local forest officers who know their plants well in the way of helping other forest officers to increase their knowledge in this respect while, if senior officers made it clear that they considered a good knowledge of local species necessary for efficiency, it is believed that a considerable improvement would result.

As regards the second point, efforts have been made for many years to encourage forest officers who have studied their plants in the forest to prepare small simple floras, each one of which dealing with a small area and therefore a restricted number of species and in which forest characters are utilized as far as possible in the keys and descriptions. With the object of accelerating this work a scheme for the systematic preparation of descriptive lists of species was drawn up by the Forest Botanist in 1913 which subsequently received the sanction of the Government of India (see *Forest Bulletin* No. 23, Calcutta, 1914). Descriptive lists of this kind, provided with useful keys, are really very efficient local forest floras

and it is believed that such pocket companions for the field dealing with restricted areas will always possess a permanent value of their own. The first lists issued under this scheme were those for the 3 Forest Circles of the Central Provinces by Messrs. H. H. Haines and D. O. Witt which were published at Allahabad in 1916. A striking testimony to the value of these lists is afforded by the fact that although the Bombay Presidency is provided with two excellent detailed regional floras yet a Divisional Forest Officer serving in a Bombay district adjoining the Central Provinces recently informed the writer that he found the list dealing with the adjacent area of the Central Provinces more generally useful to him in his work than the Bombay floras. Similar lists, but in a preliminary form, were under preparation during the year for the United Provinces by Mr. A. E. Osmaston and Mr. P. C. Kanjilal. This work has also been carried a definite stage further during the year by the completion of a local forest flora for the Andamans by Mr. C. E. Parkinson, a former forest student of Dehra Dun. Mr. Parkinson's work has materially increased our knowledge regarding the species of the Islands. Four new species have been discovered and more than 180 of the indigenous species described in his book either have not been mentioned at all or have not been reported as occurring in the Andamans in Brandis's *Indian Trees*. Mr. Parkinson's work has also indicated that several species which have been previously recorded for the Andamans probably do not occur in the Islands and that the well-known Andaman marble-wood is not yielded by *Diospyros Kurzii*, Hiern, as has been hitherto thought to be the case. The following books were under preparation during the year: the *Flora of Bihar and Orissa* by Mr. H. H. Haines, a revised edition of the *Forest Flora of the Punjab* by Mr. R. N. Parker, a *Forest Flora and Descriptive Lists for Assam* by Rai Bahadur Upendranath Kanjilal. During the year 154 specimens were identified at Dehra Dun for inquirers and Mr. Parker, the systematic botanist, made a special study of *Dipterocarpus*, *Acacia* (groups *cacia* and *oburnea*), *Berberis* and exotic species cultivated in India.

Pathology.—A careful study has been carried out by the Assistant Forest Botanist Mr. Abdul Hafiz Khan in co-operation with forest officers in Madras with reference to the location and progressive accumulation of starch in the tissues of spiked sandal and the question as to whether spiked plants ever recover from the disease.

Publications.—The *Regeneration of Sal Forests* by R. S. Hole, Forest Recrds., Volume VIII, Part II was published during the year and work was continued on the *Botany Manual* by the Forest Botanist and his staff.

Herbarium.—2941 specimens were added to the herbarium during the year the chief contributors being Messrs. C. G. Rogers, Chief

Conservator of Burma, R. N. Parker, A. E. Osmaston, P. C. Kanjilal and Mr. B. L. Gupta, Assistant Forest Botanist.

Library.—86 volumes exclusive of periodicals were added at a cost of Rs. 823.

Tours.—The Forest Botanist toured in the United Provinces during the year visiting the Haldwani and Etawah Divisions in August and the Ramnagar Division in November.

126 consignments of seeds of 88 species were made in fulfilment of indents during the year.

Education.—Lectures were given as usual to the Provincial Classes during the rains by the Forest Botanist and by the Assistant Botanists Messrs. B. L. Gupta and Abdul Hafiz Khan; the Forest Botanist conducted the botanical examinations of the senior Provincial Class and Mr. R. N. Parker those of the Ranger Class in March. The botanical examinations at the Cawnpore Agricultural College were carried out by the Forest Botanist and the Assistant Forest Botanist Mr. B. L. Gupta in April 1921.

The Forest Botanist held charge of the branch throughout the year. Mr. R. N. Parker joined the branch as systematic botanist on December 6th, 1921.

Assam.

Oecology.—Observations made in the frontier tract on the requirements of *Terminalia myriocarpa* indicate that the species requires a good soil free from organic matter and plenty of light, any direct overhead shade appears to be fatal. Existing forests of this species have arisen chiefly on the heavy deposit of silt which is brought down by the rivers and causes the death of any existing vegetation. It is therefore necessary to reproduce in the forests as close a condition to that which exists in nature in order to ensure the regeneration of the species. *Kayca assamica* has been observed to thrive best on light soils, namely loams with a very high percentage of gravel in admixture and wherever these conditions obtain its germination and reproduction are excellent.

Burma.

A new edition of Mr. Lacey's "List of trees, shrubs and principal climbers, etc., recorded from Burma," containing much additional information, was prepared by Mr. A. Rodger and was in the Press at the end of the year.

Work in the Botanical Garden at Majmye continued during the year, but on a small scale only, owing to want of funds and to the absence of Mr. Cooper, the Superintendent, for considerable periods at Rangoon,

Mr. Cooper, who was in charge of the Herbarium at Maymyo, had little time to devote to it and practically no progress was made.

The following bamboos were found in flower in the Tenasserim Circle during the year and many specimens were collected :—

Oxytenanthera nigrociliata over considerable areas.

Oxytenanthera albociliata over considerable areas.

Oxytenanthera parvifolia one clump found in Thauγγyin.

Cephalostachyum pergracile here and there.

Dendrocalamus strictus here and there.

Dendrocalamus membranaceus here and there.

Dendrocalamus Brandisii here and there.

Bambusa arundinacea here and there.

Tubindaing (not yet identified) here and there.

Bambusa polymorpha occurs in the north of the Thaton district but was not found in flower. It has a curious form of growth, many of the culms being crooked.

A bamboo in flower called *walhabut* was collected in the Karen hills of Toungoo, and the same bamboo was sent from West Salween as *wanuc*. This was supposed to be *Tecinostachyum Helferi*, Gamble, but the Forest Botanist reports that this name is incorrect and it may be a new genus. Good specimens were called for to settle the matter.

A large number of specimens were collected by forest officers in the Tenasserim Circle and the majority of these were verified at Calcutta, Dehra Dun or Maymyo. *Hura Crepitans*, L. was found at Mergui and had not previously been recorded from Burma.

Enquiries were made in various parts of Burma as to the abundance of oaks and chestnuts which could provide tanning materials. Although there are many species and these trees are widely distributed, it appears that they do not occur over large enough areas anywhere to make their commercial exploitation possible.

A botanical survey of the very valuable and almost unknown hardwood forests of Mergui was begun, sets of botanical specimens and corresponding timber specimens being collected.

The Divisional Forest Officer, North Toungoo, sent to Dehra Dun specimens of teak damaged by a fungus. The Forest Botanist reported that the specimen showed a sporophore of the common Saprophytic fungus *Scl. Longii*, but no signs of any parasitic fungus attack.

A very useful sample of One Hundred Common Trees of Burma by Mr. C. B. Stables was published during the year, after having been delayed by the faulting of the first impression.

CHAPTER IV.

FOREST ECONOMICS.

Central Institute.

The year 1921-1922 saw a complete evolution in the Economic Branch due to the inauguration of several new sections, the work of which will be dealt with hereafter. At the close of last year specialists arrived in India to take charge of the Sections of Timber Seasoning, Timber Testing, and Paper Pulp. An officer of the Imperial Service started the Section of Minor Forest Products, while the post of Wood Technologist was filled at the end of the year under report. Of the Upper and Lower Grade Assistants' posts sanctioned, only an Upper Grade Assistant to the Officer in Charge, Timber Testing, was appointed, while Lower Grade Assistants to both, Timber Testing, Seasoning and Paper Pulp were appointed. A certain number of computers, and machine operators were also engaged and a Wood Worker was appointed by the Secretary of State. The above staff by no means represents that required for all the Sections, and though it was fully realised that it was most necessary to fill the other appointments, the financial stringency rendered it impossible to do so.

With the exception of a portion of the Paper Pulp Plant, all machinery belonging to the various Sections, purchased in England and America, was received during the year under report. The work of checking and housing this experimental plant took up a great portion of the various officers' time, while further delay was caused by the housing accommodation being extremely limited. It was hoped that during the last cold season the laboratories and workshops on the new site would be ready for erecting the plant, but this was not the case, and therefore the greater part of the machinery had to be put in store. On the other hand it was thought advisable to erect as a temporary measure such machinery as was possible in the existing workshops and outhouses of the present Institute in order to carry on what work was possible in the limited space available and to train a nucleus of machine operators.

The major portion of the Forest Economist's time was taken up in organising the various Sections and making the necessary arrangements for erecting, as a temporary measure, the Timber Testing and Wood Working machines it was possible to use in the existing buildings. The Forest Economist was also employed in preparing plans and lay-outs for the new laboratories and workshops, which are now being erected and the only to be a short time to Delhi with the Officer in Charge, to advise on the seasoning of timber in New Delhi, the Utilization Workshops at Bareilly, visit to attend the Conference of all the Railway Engineers

in Simla, a visit to Calcutta to give evidence before the Fiscal Commission and a more extended tour to Burma, at the request of the Local Government, to submit a report on their future policy in connection with Economic research.

A feature of the year's work was the first Utilization Conference held in India, which was largely attended by officers from all provinces. At this Conference the future policy of Utilization Circles and the development of Economic Research at the Central Institute were fully discussed. This meeting marks one of the most important advances in Forest Utilization in India.

There can be no doubt that though much has been done during the year under report to develop the Economic Branch, considerably better results could have been obtained had (1) the new laboratories and buildings been ready in which to erect the machinery and so allow the Sectional Officers to make the best of their opportunities and (2) had Imperial and Upper Grade Assistants been appointed to the various Sectional Officers and thus give the specialists more time to train their Assistants to undertake the work when the new laboratories and workshops are a running proposition.

It is gratifying to be able to record the great increase in the number of enquiries which have been received both from officials and from the commercial world, on subjects connected with all branches of our work.

In order to assist interested parties a Trade Supplement to the "Indian Forester" is now issued monthly, this supplement is the outcome of a quotation list formerly published at the end of the Indian Forester and which has been gradually amplified year by year. This new departure in issuing a supplement has been well received by the commercial community as is verified by the number of copies applied for.

The inadequacy of the clerical establishment has been a source of continued difficulty and has considerably hampered the correspondence work which has to be carried on with the commercial world.

II. EXPERIMENTAL AND COMMERCIAL ACTIVITIES.

1. Section of Wood Technology.

Dr. Brown, who recently joined the Forest Research Institute as Wood Technologist, is about to prepare keys based on gross and microscopic features for the identification of our more common commercial timbers, and a laboratory is now being fitted up. It is hoped at the end of the year that it will be possible to report substantial progress in this most important Section of our work. The only work connected with Wood Technology that has been carried out in the absence of a specialist has been the identification of timber as they have come to hand from various enquirers.

ordinary
insects, but may be kiln seasons



and arrangement as to piling, steady heating and
air within the kiln. The temperature, humidity and
may be controlled and regulated to get good results.

Photo I. A kiln similar to the above, capable of
shooks or 2 tons output per la-

Its greatest usefulness is probably in connection with small

2. Section of Timber Seasoning.

The Officer in Charge, Timber Seasoning, was very fully occupied during the year in spite of the fact that his seven drying kilns are not yet sufficiently advanced in construction to permit of erecting the internal machinery connected with these plants. He spent three months at Bareilly, putting the seasoning kilns of the Wood Working Institute into working order, training two kiln operators and seasoning some 5,000 specimens of timber to be tested for cotton bobbins. In April 1921, he was sent, at the request of the Chief Engineer, New Delhi, to enquire into and submit a report on the seasoning of timber being used in the construction of the buildings at Raisina, and the result of this report is likely to have far reaching effects. As an outcome of an enquiry from Bengal concerning the seasoning of tea-box woods a temporary semi-portable kiln was erected at the Central Institute in which to carry out the necessary experiments. This kiln was also erected with a view of demonstrating the uses, possibilities and limitations of such kilns to the officers attending the Utilization Conference. The results obtained in this kiln with soft woods were highly satisfactory. Mr. Sweet made an extensive tour in the United Provinces, Madras and Coorg to check the results of the natural seasoning experiments which had been in progress during the last two years and has since been engaged in writing up the results, his report will shortly be submitted.

At the request of the Director of Ordnance Mr. Sweet paid a visit to the Jubbulpore Gun Carriage Factory and carried out a preliminary investigation in connection with the seasoning of their timbers which has resulted in a project being submitted to the military authorities making proposals for a more detailed enquiry into the subject.

The work already carried out by the Officer in Charge Seasoning has led to a number of enquiries being made both by officers of the Forest Department and by timber users, and it may be said that a very satisfactory start has been made with this most important branch of research.

3. Section of Timber Testing.

The Officer in Charge, Timber Testing, began his work during the year under report by the erection of four testing machines in the workshop. This took up a considerable amount of time, as it was found that, due to the alternating supply of electric current available at Delhi, new speed gears had to be designed and procured, while as the machines were being erected they had to be carefully calibrated. All the specimens selected with timber testing had also been calibrated and the Officer in Charge has since been engaged in a complete programme of work which laid down the procedure for the testing of timber which all routine tests

should be carried out, and which, with minor modifications, eventually received the sanction of the Inspector General of Forests. This scheme of working will in future be known as Project I. of this branch of the Forest Research Institute. As soon as the machines were in running order the first series of tests were carried out on behalf of the Punjab Government to ascertain the relative value of the red and white wood of spruce which resulted in clearly demonstrating that the red wood was equally as strong as the white and could therefore be used, after treatment, for railway sleepers. The next set of tests carried out was for the Utilization Circle, Bareilly, who had prepared a number of hammer shaft woods of various species which it was hoped might be suitable substitutes for imported handles. The tests conclusively proved that the Indian substitutes were in every way suitable for the purpose. Conjointly with carrying out hammer shaft tests, routine tests according to Project I were carried out on green Malabar and Central Provinces teak, while the Burma variety will be taken up as soon as it comes to hand. The tests according to Project I on *Terminalia tomentosa* have also been started and will be continued until complete. The next series of tests carried out were for a firm in Calcutta on plugs for concrete sleepers in order to determine suitable woods for the purpose and *Acacia arabica* was found to answer the purpose fairly well. Following the spike pulling tests on plugs, similar tests were carried out on silver fir and deodar sleepers in order to compare the relative value of the former with a timber of standard species. Again, another series of spike pulling tests were carried out on *pyinkado*, *Xylia dolabriformis*, at the special request of the Agent of the Burma Railway. At the request of the Madras Government a series of strength tests were carried out on four species and the results will shortly be submitted. Towards the close of the year the Burma Oil Company asked for tests to be carried out with a view of finding substitutes for hickory used for Sucker Rods in oil wells, and an extensive enquiry is in progress.

The total number of tests carried out during the year were as follows—

Spike Pulling Tests on 7 species	159
Project O on 11 species—	
1. Mechanical Tests	1,545
2. Physical Tests	1,274
Project I on 11 species—	
1. Mechanical Tests	915
2. Physical Tests	1,031
Total Mechanical and Physical Tests	2,795
Sucker Pulling	150

It can briefly be said that the results of the tests carried out during the first year of working have more than justified the engagement of a specialist for timber testing and the purchase of several expensive testing machine. To take one example, the very first tests carried out on red and white wood of spruce proved that red wood could be used as well as white wood for sleepers, thus allowing the Punjab Government to supply nearly 50 per cent. more sleepers of that species for treatment to Indian Railways.

4. Section of Minor Forest Products.

Satisfactory progress was made in consolidating the work of this section and at the same time the preliminary detailed work in connection with the forthcoming Empire Exhibition was carried out. In order that the Officer in Charge, Minor Forest Products, when starting the section should have as wide a knowledge as possible of all conditions in various parts of India and also to enable him to make the preliminary arrangements with the local Forest Officers in the various provinces in connection with the Empire Exhibition, he proceeded on tour early in November and visited Bengal, Assam, Bihar and Orissa, Burma, the Andamans, Madras, Bombay and the Central Provinces.

The question of utilizing *Boswellia serrata* gum-oleo-resin has been under consideration and experiment for a number of years, and during his tour the Officer in Charge, Minor Forest Products, took steps to develop the industry in the various provinces and it is thought has succeeded in developing an export trade in the raw material until such time as a start may be made to refine it in India. As regards the progress of the enquiry it may be said that negotiations for a lease by a firm are in progress in the Bombay Presidency, while the erection of a solvent plant to deal with the separation of gum-rosin and turpentine is now being erected by the Gwalior Durbar, the results of which will be watched with interest.

Experiments are in progress for tapping gums of the *bassora* or *tragacanth* series and much attention has been paid to this subject during the year under review. Another enquiry which may lead to important results is in connection with the leaves and bark of *Vitex peduncularis*; correctly identified material has been distributed by the Medical Research Department with which the Minor Forest Products Officer is working in collaboration.

Other enquiries in connection with local fibres, as substitutes for imported material used by Indian brush factories, have been in progress, while the work on Copals, in which considerable interest is taken, has been much delayed due to want of staff both in the Minor Forest Products Section and the Chemical Branch.

A trade index is being prepared and is making satisfactory progress. Mr. Robertson, the Officer in Charge of this Section, has

rendered much assistance to the writer especially during the time when the Assistant Forest Economist had to be temporarily lent for instructional duties.

5. Section of Wood Utilization.

Owing to the workshops and testing laboratories not being in full working order the number of experiments carried out with the object of finding new uses for timbers, or substitutes for imported wood, were confined during the year under report to an extensive enquiry in connection with possible hobbin woods from Madras. The timber was sent in the log to the Utilization Circle, Bareilly, where it was converted into rough hobbin pieces and seasoned in steam kilns by the Officer in Charge, Seasoning, and then sent to England to one of the biggest hobbin factories to be tested. The report on these woods is now awaited. Similarly a number of Madras woods were sent to the Utilization Circle, United Provinces, where they were converted, seasoned and tested for casks of which, however, only one or two showed any promise at all.

A large number of enquiries were received from firms as to woods suitable for a variety of purposes and information was supplied wherever possible from experience gained from former experiments. Until we have our Sections of Wood Technology, Timber Testing, and Seasoning fully organised and their laboratories and workshops complete, we shall not be in a position to give the best information possible to enquirers who seek information as to suitable woods for special purposes.

6. Section of Wood Preservation.

In the absence of a Wood Preservation Specialist neither was the experimental pressure plant erected nor were any new experiments inaugurated. On the other hand the annual inspection was made of the experimental sleepers laid in open lines in order to determine the durability of various Indian timbers after treatment, and in this connection inspections of experimental sleepers were carried out in Burma, and near Lucknow, Haridwar, Quetta, Ferozepore and Sukkur. These experiments have now been in progress for ten years and may be said to have given very satisfactory results to date. The writer attended a meeting of all the Chief Engineers of Indian Railways at Simla, when the whole subject of treatment of sleepers was very fully discussed and, after the results of the above mentioned experiments had been fully explained, a resolution was passed by the conference advising the erection of treating plants at all suitable centres in India. Results of the experiments may therefore be said to be gratifying. The North Western Railway authorities, as a result of our experiments, are erecting a large creosoting plant, while

at least three other Railways in India have similar projects under consideration.

Two comprehensive notes on the results of these experiments have been prepared, one of which will be issued as a Forest Record and the other, drawn up at the request of the Chief Engineer of the Railway Board, will be published as a technical report by the Railways. The urgency of obtaining the services of a whole-time man to deal with this subject becomes daily more apparent.

7. Section of Paper Pulp.

The experimental pulp and paper plant which was ordered by Mr. Raitt, while on deputation in England, came to hand during the year, with the exception of a portion of the paper making machinery which is shortly expected to arrive in Dehra Dun. This plant has been checked and carefully housed.

Enquiries received on the subject of supposed deterioration of *sabai* grass for the manufacture of paper pulp have led to a series of laboratory experiments being carried out to verify these assumptions and also with the object of improving the present methods of treatment in order to increase the yield and to reduce the amount of bleach necessary.

An enquiry was carried out at the instigation of the Bihar and Orissa Government as to the possibilities of working bamboos for pulp in the Angul, Sambalpur and Singhbhum Divisions of that province and the Officer in Charge, Paper Pulp Section, carried out a tour in that locality with the object of determining the principal factors governing the possibility of starting such an industry. The enquiry is now pending a field survey as to outturn, which is being carried out by the local officers.

At the request of the Superintendent of Jails in the two provinces of Bihar and Orissa and Central Provinces, the Officer in Charge, Paper Pulp, carried out an enquiry as to improvement in the methods adopted in the manufacture of hand made paper in the Central Jails and a report with recommendations was submitted on the subject.

The year under report has been signalized by an increased number of enquiries as to possibilities of starting pulp and paper factories at various localities. Schemes are under contemplation in Western and Southern India, in Gujarat and the North-Western Provinces, in Chittagong and in the United Provinces.

8. Section of Tans.

The Officer in Charge Tans has been working in Burma throughout the year and has carried out a survey of chestnut and oak barks, leaves and woods in the neighbourhood of Maymyo and is about to

prepare an exhaustive report on the subject. He has also carried out a considerable number of tests on various *Dipterocarps* and *Terminalias*, and on completion of which work he will proceed to Mergui in the Tenasserim Circle to carry out a survey of the mangroves in that locality.

Mr. Pilgrim was on leave during a part of the year, which somewhat curtailed his activities, on the other hand he made arrangement for routine tests to be carried out by Mr. Pasupati, his assistant, and also has collected large samples of tan stuffs of a variety of species with which to tan specimen hides for the 1924 Empire Exhibition.

9. Sub-Section of Wood Working.

As soon as a Wood Worker was appointed from England, arrangements were made for the erection of some of the wood working machinery which had come to hand, but as the temporary sheds available were hardly sufficient even to take a portion of the machinery an extension had to be made of a quite temporary nature in order to allow any work at all to be carried out. It should be mentioned that the erection of these machines as they now stand is only a temporary measure, aiming at employing the available staff and especially directed towards training machinists before we move over into the new buildings.

In spite of the very cramped space available, a great deal of useful work has been carried out during the year as no less than 280 orders placed by the various Branch and Sectional Officers have been executed. At the same time a very good nucleus staff has been trained in handling the various machines.

Of the more important work carried out the following may be mentioned :—

Erection of a temporary seasoning kiln, of temporary godowns, shingling the existing workshops, partly as an experimental measure and partly to reduce the heat under the galvanized iron roofing.

Of articles prepared and which entailed considerable work the following may be mentioned :—

12 filing cabinets for various Branch and Sectional Officers.

3,000 specimens for Timber Testing.

450 air-tight insect specimen boxes for the Forest Entomologist.

4 book cases, two for the Forest Chemist and two for the Library.

Complete internal fittings for the Timber Testing shops including four large admirals.

4 special cabinets for the Botanist.

4½ dozen plotting boards for the Silviculturist.

6 special callipers for Working Plans Officer, Bihar and Orissa.

The above is sufficient to show the variety and extent of the work carried out by the Wood Working Sub-Section and it may further be stated that after careful checking of cost of production the costs work out to about 50 per cent. less than when the same work is given out on contract.

The Wood Museums and Minor Forest Products Collections were kept up to date and added to during the year, though it is not possible now to make very large additions until the new museums are built as the accommodation available is insufficient.

Bengal.

Mechanical Extraction and Conversion at Sukna, Kurseong Division.—The operations which have been started in the Sukna sal working Circle to determine the possibilities and value of mechanical extraction in small clear felled coupes in the flat foot-hill forests of North Bengal, were continued during the 1921-22 season.

The area cleared was one of only 25 acres and extraction could not commence until January, owing to delay by the railway company in extending the line into the new coupe. As mentioned in last year's report, the D. II. Railway has laid and extends and maintains this forest spur from the Sukna station, free of charge to the Department, in consideration of the freight earned on the transport of sal logs to Siliguri, 7 miles distant, and box planking and fuelwood to tea gardens in the hill sections of the railway.

The improvised skidder was run from January 14th until the end of March and achieved the results given below, which show that even in such small coupes distinct advantages arise from the use of mechanical means of extraction. The difficulties experienced were due to the fact that the machine and tackle are old, are not designed for and are not strong enough for the heavy work (most of the logs are 32' in length and many weigh more than a ton); the machine has only one cable drum and the cable has to be hauled out by a coolie gang to the logs. Shortage of water, insufficiency and lack of skilled labour in the district and irregular supply of log cars, owing to the railway strike, seriously interfered with the work and prevented a fair test being made. The results were :—

No. of logging days from January 14th to March 20th	60
	c. ft.
Volume of logs hauled in and loaded on cars	10426
Volume of logs hauled in but not loaded	5914
Average Volume of logs hauled in and loaded per diem.	223.5

The value of the plant in use during this half season's work was Rs. 6,082 and the daily labour bill for the engine man and 11

coolies was Rs. 5-13-0, the total cost of extraction being made up as follows :—

	Rs.	A.	P.	
1. Felling, dressing and log making ...	0	1	0	per c. ft. log.
2. Labour cost of hauling in and loading ...	0	0	5	
3. Depreciation and maintenance (20 per cent. per annum).	0	0	8-3	
4. Railway freight to Siliguri station ...	0	2	3	
Total cost from Tree Stump to Siliguri station ..	0	4	4-3	
5. Additional freight from station to log depôt ..	0	0	2	
6. Unloading by hand in Siliguri log depôt ..	0	0	6	
Total cost delivered in Siliguri log depôt ...	0	5	0-3	

The cost of felling, dressing and carting from Sukna to Siliguri by road is 6 annas per c. ft. of log, so that a saving of from 1.5 to 1 anna per c. ft. results from the employment of mechanical methods. In addition there is the enhanced value of the large logs handled; the value of a 32' log in Siliguri depôt is Rs. 2-8-0 per c. ft., whereas for logs of a size which can be man handled and carried on bullock carts it averages only Rs. 1-10-0 per c. ft. Furthermore the difficulty in securing a regular and sufficient supply of carts to remove all the sal felled in these coupes, is overcome.

Tree tops, branches and debris from the felled area were prepared for fuelwood by hand; it was loaded into large bogie cars by coolies and despatched to tea gardens in the hills. The demand for fuelwood is considerable and this branch of the utilisation work resulted in a clear profit to the Department, besides the usual royalty, of Rs. 1-12-8 per 100 c. ft. of stacked wood.

The small American portable saw mill was not run before April 1922 owing to a shortage of labour, but during 28 working days in that month 21,000 sq. ft. of half inch planking and 150 c. ft. of seasoning sticks were sawn from 274 logs of 2,050 c. ft. volume. Difficulties due to insufficient equipment, delay in obtaining spares, lack of skilled labour and irregular supply of water and logs arose but the output in a working day of 7 hours averaged 1,000 sq. ft. and on occasions exceeded 1,500 sq. ft. The daily labour cost of 1 fitter and 14 coolies amounted to Rs. 8-11-0 and the labour cost of sawing the planking was Rs. 9-8-0 per 1,000 sq. ft., compared with Rs. 28 which had to be paid for hand sawing in this district. The trial shewed what additional plant and alterations are necessary to the mill to reduce the crew, decrease the number of delays and assure a daily output of from 1,500 to 2,000 sq. ft. During next season it is hoped, with the additional plant, to run the mill continuously from October to May, with an average output of 1,500—2,000 sq. feet a day for 200 days. The mill will then convert the whole of the softwoods felled in the coupes, it will enable the full royalty rates to be realised and will give a clear profit of from Rs. 1,600 to Rs. 3,600 for the season. Hand sawing at Sukna is expensive and there are insufficient sawyers to convert the whole of the softwoods felled into planking.

with a market value. The high rate (Rs. 28 per 1,000 sq. ft.) for handsawing and the high wastage would not allow the full royalty rates being realised on what timber could be converted and there would be no clear profit to the Forest Department. The demand for tea box and orange box planking in the district is considerable and a market can readily be found for the output from several mills similar to that at Sukna.

Bihar and Orissa.

The only research work carried out in Hazaribagh Division during the year 1921-22 was the tapping of *salai* (*Boswellia serrata*) for resin. As the work will not be finished until the rains, no statement can as yet be made regarding its prospects. So far the flow of resin has been below expectations (2½ maunds collected to date) but this is due to the fact that the trees which yielded poorly were not eliminated after the first few freshings. One thousand selected trees were tapped and freshed every 4 or 5 days. It was largely with the object of collecting further data of the yield that all the trees were freshed whether their yield was good or bad. When working is commenced on a commercial scale it will of course be necessary to eliminate all trees which yield poorly after the third or fourth freshing.

Tapping of *Sterculia urens* in Angul Division. At present experiments are in progress in order to ascertain—

1. Best method of tapping.
2. Effect of tapping.
3. Cost of extraction and outturn.
4. Most favourable season.

The experiments were started in September 1921 with 7 trees.

The following methods of tapping were tried :—

1. Puneturing of bark in narrow slits.
 - (a) Slits cut parallel to the axis of the tree.
 - (b) Slits cut perpendicular to the axis of the tree.

2. Removal of bark to different depths varying from ¼th of an inch to about 1" or to the cambium layer.

3. French method of tapping pine for resin.

It can be safely said from observation during this period that the first and third methods can be discarded. It should be mentioned that gum has been seen exuding in the form of what may be termed "tears" from slight cracks. Though the colour of this gum the exuding is pure white, the quantity is insignificant and hence of no use commercially. Horizontal or oblique slits give more gum than vertical slits.

Description of Method No. 2.

The only tool used was that of a carpenter's chisel. Several parallel oblique slits are cut with the chisel. A slit is about $1\frac{1}{2}$ " broad at the top and narrows down to a fraction of an inch at the bottom. The length of a slit depends upon the girth of the tree, that is, the bigger the girth, the longer the slits will be.

It has been observed that this method gives the largest quantity of white gum.

Gum has been collected and sent to an interested firm and to the Forest Economist, Dehra Dun.

It has been graded as follows :—

1. White or nearly so.
2. Brown, and possibly into a third grade of dark gum.

It is interesting to note that gum which may be pure white at the time of collection turns pale yellow if left for a few days. Collections were made at various times, that is, a few days after tapping when there has been no rain during the interval and also when there has been rain. Gum in the latter case was discoloured brown on the tree, while it remained white or nearly so in the former case. The Forest Economist to whom both these samples were forwarded was inclined to think that "the brown discolouration is probably due to tannin from the bark passing in solution into the gum and undergoing oxidation there." The writer is of the same opinion. Samples have been forwarded to the Indian Institute of Science for examination.

It is interesting to note that exudation starts immediately after the slit has been cut into the tree.

No definite opinion can be given yet as regards the effect of tapping on the tree, the cost, and outturn per tree. Experiments are in progress in order to ascertain these points. As soon as these data are complete a report will be prepared.

It may, however, be useful to indicate briefly the lines on which the experiments are going on. Ninety (90) trees have been tapped as explained under method No. 2, girth of each tree tapped been noted. The trees have been divided into three lots. Collection from one lot will be made every fifth day, from the other every eighth day and from the third every tenth day. All the trees are serially numbered. Gum collected from each tree is weighed and entered against the particular tree. Weighing and entering in specially prepared tabular form is done by the office. Slits on half of the trees of each lot will be freshened after collection while on the other half the slits will be left unfreshened. This experiment will be carried out throughout the year and it is hoped by then to collect sufficient data to achieve the purpose aimed at.

Burma.

(1) *General working of administration.*—The remarks under this head deal with administration only in so far as economic research and experiments are affected and not with the general administration of the Circle.

During the year under report progress was made with constructional work and proposals were submitted for a new division under the Utilization Circle to be known as the Timber Research Division. Sanction had however not been accorded at the close of the year. These proposals arose out of the visit and subsequent report made by Mr. Pearson, Forest Economist, Dehra Dun, who visited Burma to advise on the subject. His full report has been submitted to the Local Government in connection with the plans and estimates of buildings, etc. at the Forest Depot, but summarised his recommendations, (which have been accepted by the Forest Department and recommended to Government) are as follows:—

- (1) An extension of the existing saw-mill to make it capable of an output of about 10 tons a day.
- (2) Seasoning experiments in the Tieman dry kiln.
- (3) Extensive natural seasoning experiments in sheds.
- (4) General woodworking workshop.

Mr. Teesdale, the Timber Seasoning Expert, will be in charge of the seasoning experiments and proposals for a suitable staff to assist him in his work have been submitted. Mr. Watson, one of the newly appointed Forest Engineers who has had considerable experience of sawmill practice, arrived on December the 16th 1921, and, since the departure of Mr. Craddock on leave on medical certificate, has been in charge of the sawmill work and will be placed in charge of the Timber Research Division when sanctioned. For the woodworking workshop Mr. A. Cogger was engaged last year and arrived in Burma on July the 2nd, 1922. A nucleus of the ultimate staff required for the Timber Research Division has thus already been got together and as soon as the sanction of the Local Government has been obtained to the formation of the Division, and to the plans and estimates for the buildings and machinery required, steps will be taken to recruit the necessary subordinate staff in each section and to push on with the erection of the buildings and machinery. Much of the latter has already arrived, though some few items still remain to be purchased. This will give effect to Mr. Pearson's recommendations which, as remarked above, have been unanimously accepted by the Forest Department. At this stage it is not considered that any further remarks concerning the general work of administration can usefully be made.

(2) *Experimental activities.* (i) *Wood Technology.*—Nothing has been done in the year under report.

(ii) *Timber Seasoning.*—One shed has already been built and the others recommended by Mr. Pearson, will be put in hand as

soon as sanction is received. A good deal of timber of various species had been collected for shipment to Europe but when Mr. Alexander Howard visited Burma in January last he recommended that as some of it had deteriorated considerably it would be advisable to convert these logs at once and this was done, the conversions being carefully graded into those suitable for shipment to Europe and those only suitable for local sale. Both qualities were carefully stacked in the seasoning shed and were kept under the continuous inspection of Mr. Teesdale who took specimens from time to time to test the moisture content. The experiment is still in its infancy and it must be borne in mind that the logs from which the conversions were made had already been seasoned in the open air for some considerable time. The results so far have been quite satisfactory and the planks showed little tendency to split or crack. Whilst none were bad the most promising results were obtained from *thitsi* (*Macanorrhoea usitata*) which gave evidence that it would dry very well under cover without splitting or cracking. Other timbers converted were *thitkado* (*Cedrela Toona*), *thitka* (*Pentace burmanica*), *yemane* (*Gmelina arborea*), *kaunghmu* (*Parashorea stellata*), *padauk* (*Pterocarpus macrocarpus*) and *yindaik* (*Dalbergia cultrata*).

3. *Timber Testing*.—Nothing was done in this direction and on Mr. Pearson's advice the 100,000 lb. testing machine has been transferred to Dehra Dun where it will be utilised primarily for such tests of Burma timbers as may from time to time be asked for by this province. The 30,000 lb. machine has been retained for use by Mr. Teesdale in connection with his seasoning experiments but it is not now intended that extensive testing experiments shall be conducted in Burma as it has been pointed out that this can be better done at Dehra Dun.

4. *Wood Preservation*.—There are no schemes at present under consideration for the preservation of wood by impregnation as a Government enterprise. It is possible that this may be undertaken later when the Timber Research Division has developed further. Messrs. A. V. Joseph & Co. have erected an open tank plant for the creosoting of sleepers but it has not yet been in operation for very long and results are still awaited.

5. *Minor Forest Products*.—There do not appear to be any records in this office of any activities during the year under report in this Circle. The Delta Circle reports that samples of fibre of *thinban* (*Hibiscus tiliaceus*) were sent to Calcutta for testing by a firm interested in rope making but were reported as useless.

6. *Paper Pulp*.—In last year's Annual Report it was noted that concessions had been granted to 5 firms for the manufacture of paper pulp : of these, Messrs. Heilgers, in the Pegu District, have not commenced work, partly owing to the general depression in trade and partly owing to the area finally allotted to them not

proving in all respects satisfactory: Messrs. Jamal Bros'. mill which was never very satisfactory was destroyed by fire and up to date work has not been recommended: Messrs. Hockley and Manning were unable to commence work in Tavoy and applied for a further extension of their option which has been granted.

As regards the two concessions in Arracan neither of the concessionaires started work and it is understood that both have been given a time limit in which to commence work or give up the concession. The Conservator, Delta Circle, states that in his opinion neither is likely to undertake operations. The position therefore with regard to paper pulp is that no firm is at the present moment working in the province.

7. *Tans*—It appears improbable that any commercial results will be obtained from the use of the various species of *Cassia*, experiments with which were inaugurated during the war.

8. *Wood-working*.—Nothing has been and nothing can be done until the woodworking shop is completed and is in operation. It is then intended to experiment with any timbers which may appear to possess the desired qualities in the manufacture of tool handles, turned articles, furniture, panelling, flooring blocks, etc. At the outset samples only will be produced in fair quantities and it is intended to distribute these to firms and individuals likely to be interested with a view to their being tested. When a suitable timber is found for any purpose, commercial samples will be manufactured in fair quantity and if the experiment is so far successful that these are approved by the trade, the timber will then be widely advertised and private enterprise invited for its exploitation.

9. *Miscellaneous*.—The Forest Museum at Rangoon was open to the public until about the middle of March, when notice was given that the building in which it was housed would have to be dismantled owing to the operations of the Rangoon Development Trust. The Museum was in consequence closed, the more fragile exhibits being transferred to the office of the Conservator where they are on view and available for study by persons wishing to see any particular article. Being in the office however, the collection is not at the moment available for inspection by the general public. The heavy timber specimens have been temporarily stored and up to the time of writing it has not been found possible to rent a suitable building for the reopening of the Museum. As it is intended to erect a small exhibition room in connection with the wood-working section of the Timber Research Division it is probable that when the building is erected the collection of the Museum exhibits will be placed on exhibition there, pending the erection, by the Development Trust of a Provincial Museum which is to contain a forest section and which will ultimately house the Forest Museum collections. The temporary closing of the Museum is much to be regretted as it had attracted a large number of visitors and appeared to be fulfilling a useful purpose.

Central Provinces.

Timber Seasoning.—Sufficient experience has now been gained to show that teak, *haldhi* (*Adina cordifolia*), *tiwas* (*Ougeinia dalbergioides*), and *bija* (*Pterocarpus marsupium*) will not season here in the log and consequently all departmental operations are now being so arranged that logs reach railhead as speedily as possible after felling. This saves considerable loss from splitting which is otherwise very serious in this locality where rapid changes in air humidity are frequent.

Timber Testing.—Five teak logs were despatched to Dehra Dun in October 1921 for testing by the Forest Economist's branch.

Minor Forest Products.—7½ seers of gum *karaya* (i.e. the gum of *Sterculia urens*) were collected departmentally and despatched to Messrs. Gillanders Arbuthnot, Calcutta, for report as to whether the gum is suitable for the American palate.

(a) The department has throughout the year supplied ebony (*Diospyros melanoxylon*) and *karai* (*Sarcopetalum tomentosum*) to a billiard firm for the construction of cues.

(b) Specimens of timbers likely to be useful as dipping rods were sent to the Deputy Director of Industries, and to the Excise Commissioner, United Provinces.

Experiments in tapping *bija* trees for gum were started at Turwar, North Mandal Division. What is expected to prove a successful method of tapping which should not damage the trees has been experimented with.

Punjab.

Increased office work owing to attempts to increase inland and export trade, preparation for and erection of the second resin plant at Jallo, and extra work in connection with the transfer of the factory to the co-partnership scheme, have prevented any serious experimental work being done at the Jallo Resin Factory.

As mentioned last year the spruce red wood has been under investigation as regards its qualities and has been proved at Dehra Dun to be slightly stronger than the spruce white wood. In the Bashahr Timber Division spruce red wood sleepers are now being cut. They will be dried in the forest for one year and then floated to the depots; but owing to the fall in the value of spruce timber, it is doubtful if this will pay financially in the near future.

The result of seasoning experiments carried out in the Kangra Forest Division with *ohi* (*Albizia stipulata*) timber have been reported by the Divisional Forest Officer to the Forest Economist in detail. Seasoning in the log and by girdling trees both seem unsatisfactory; apart from damage by insects scantlings subsequently sawn show a great tendency to warp and split. Green

conversion followed by 3 months seasoning under water and 21 months under cover resulted in the least damage from insects, but green conversion followed by 2 years seasoning piled horizontally and under cover seems to give sufficiently satisfactory results all round.

United Provinces.

UTILISATION.

I.—General work of Administration.

With few exceptions utilisation work in the United Provinces is centralised in the activities of the Utilisation Circle, of which the main object is briefly to act as a sales agency or connecting link between the territorial circles and the consumers of United Provinces forest produce. To further this object a new Timber Supply Division was inaugurated at the commencement of the year, the success of which has been a marked feature of the year and the assistance given by it to territorial divisions has undoubtedly had a material effect on the Forest Revenue of the Province. The factories initiated prior to the year under review have been maintained.

At the Wood Working Institute,¹ Bareilly, experimental work on the uses of new timbers and their commercial possibilities has been continued, side by side with the educational work of training Indian labour in all branches of wood work and the use of wood working machinery.

In spite of general trade depression the Government Turpentine and Rosin Factory, Clutterbuckganj, has continued to prove a sound commercial undertaking. The successful maintenance of the Rosin Industry is of great and increasing importance, not merely to India, but to the Empire as a whole, as has been emphasised by the Imperial Institute Trade Enquiry on Gums, Resins and Essential Oils.

The Government Sawmill and Turnery, Clutterbuckganj, is now concentrating almost entirely on the manufacture of bobbins, a marked improvement in the quality of goods manufactured has been attained during the year and Bareilly Bobbins now compare very favourably with imported English Bobbins.

II.—Experimental and Commercial Activities.

Timber Seasoning.—After alterations to the seasoning kiln in the Wood Working Institute, operations commenced in August 1921. Experimental work on 32 species was carried out and commercial work on 8 species, in particular *Dalbergia Sissoo*, *Cedrela Toona*, and *Terminalia tamentosa*. Results have been generally satisfactory.

For special purposes such as cabinet making, panelling, etc., kiln-seasoned timber possesses undoubted advantages over naturally seasoned timber. Commercial enquiries for kiln seasoned planks of *Dalbergia Sissoo* for furniture making have already been received.

Minor Forest Products. (a) *Resin*.—The manufacture of Rosin and Turpentine from the resin of the *Pinus longifolia* of Kumaun has been continued at the Government Turpentine and Rosin Factory, Clutterbuckganj, and in spite of general trade depression results have been satisfactory. New distillation plant has been introduced to effect improvement in manufacture. The question of more rapid transport of resin from forest to factory, to reduce deterioration, is receiving consideration. A successful experiment was made to test the possibility of floating crude resin in receptacles hollowed out from billets of *Bombax malabaricum* and further experiments will be made.

(b) *Khas Khas roots*.—A trial consignment from Gorakhpur was sent to Messrs. Forest Products, Ltd., Cawnpore, for distillation of Vetivera oil. Owing to scarcity of the grass and high cost of collection, however, there is no prospect of success attending its exploitation from this division.

(c) *Earth Colours*.—(Red, yellow and white ochre) were extracted from the Donda Mine in South Banda Range and sent to the Forest Research Institute and other places for analysis and valuation.

(d) *Tufa Lime*.—Deposits were located in South Banda Range and it is estimated that these will yield several lakhs of maunds of a very high quality lime. They are to be worked on a long lease.

(e) *Lignite (coal)*.—A sample piece from Saharanpur division was sent for analysis by Director General of Geological Survey of India and was said to be very valuable for briquettes and coke. Further investigations are in progress.

(f) *Lac*.—With a view to introducing the propagation of Lac in Jhansi division, the Divisional Forest Officer was deputed to study methods employed in the Central Provinces and a start has been made by Government in Jhansi Division since the close of the year.

Wood Working. (a) *Turnery*.—Bobbins have been manufactured on a commercial scale in the Government Turnery, Clutterbuckganj. The quality has been improved and markets are increasing, the timber mainly used is *Adina cordifolia* at present, and this will probably be supplemented by *Holoptelea integrifolia* which has also proved very suitable. For solid turnery *Anogeissus latifolia*, *Terminalia tomentosa*, and *Shorea robusta* have been found satisfactory. Experimental turnery work with new timbers is being continued at the Wood Working Institute.

(b) *Cooperage*.—Experiments have been carried out in the Wood Working Institute with 15 species and of these available in

United Provinces, *Shorea robusta* and *Quercus dilatata* were most satisfactory.

These two species appear very suitable for beer casks and are at present being tested by a brewery firm.

(c) Furniture making continues to be one of the main activities of the Wood Working Institute and has proved very remunerative. In addition to the recognised furniture timbers, experimental work has been undertaken with a view to placing *Terminalia tomentosa* on the market for high class panelling and furniture work.

(d) *Miscellaneous Wood Work*.—Experimental work on picture frame mouldings has been carried out and a full range of such in various timbers will shortly be placed on the market; it is understood that hitherto supplies have been mostly imported from America. Stocks of *Adina cordifolia* and *Terminalia tomentosa* were specially seasoned and cut into blocks for flooring which will shortly be laid as test pieces. Wood wool has been supplied to the fruit trade also standard box shooks for fruit packing. Police batons in *Terminalia tomentosa* were made and supplied to the Police Department. Cotton reels in *Holoptelea integrifolia* and *Adina cordifolia* were made and submitted as samples. Small handles and cheap bed legs have been turned out satisfactorily from small poles of *Dalbergia Sissoo*.

(e) *Match manufacturing*.—A sample log of *Odina Wodier* was sent from Dehra Dun Division to a firm in Cawnpore at their request and was found suitable for matches.

Miscellaneous. (a) *Glue tests*.—Eleven hundred and fifty glueing tests were carried out in the Wood Working Institute in collaboration with the Forest Research Institute giving most valuable and definite results, Casein glues in particular proved very reliable.

(b) *Railway Sleepers*.—Much valuable work has been done by the Timber Supply Division in improving the organisation for disposal of railway sleepers to the various railways. As a result a considerably larger number of sleepers than usual of *Shorea robusta* have been sawn and disposed of this year. Efforts have also been made to introduce M. G. sleepers of *Terminalia tomentosa*.

(c) *Pit Props*.—A sample load of poles of *Shorea robusta* has been sent to a Colliery Company for testing, pit props and the report as to their suitability is awaited.

CHAPTER V.

FOREST ENTOMOLOGY.

Central Institute.

INSECTS OF HAZ :—*Borers*.—(a) Enumerations were continued in the forests infested by *Hoplocrambus spinicornis* to obtain comparison of the annual attack, as affected by climatic conditions and control measures. In the 1921 season the number of trees attacked

is estimated at 6,000, (i.e., 24 per cent. of the attack in the heaviest year) ; the rainfall was 117 inches, (i.e., 34 inches above normal). The rise in the total annual rainfall showed its expected effect by an increased mortality of the attacked trees, but the actual number of deaths in the seven compartments used as sample plots in 1921, was 30 per cent. of the number in 1917, a year with approximately the same rainfall. The reduction is considered to be due to the control measures initiated in 1920-21. Under all conditions of rainfall the distribution of attack is fairly uniform throughout the various girth-classes. A group of compartments was burned over by the divisional officer as a subsidiary control experiment ; the resulting attack was higher in this area than in the neighbourhood.

(b) The Insectary experiments on the correlation of rainfall and periodic emergence of the beetle were repeated, and confirmation obtained of previous results. The survival and successful emergence of the borer in sleepers, beams, rafters, slabs, etc., was demonstrated.

(c) In the Laboratory the life, fecundity, and oviposition of the beetle and the incubation, and early development of the larva were studied under variable conditions of humidity. Dry conditions were found to be unfavourable in all cases and fatal below 60 per cent. relative humidity ; extreme wet conditions are less unfavourable but optimum conditions are those of high humidity, the limits of which are not yet determined.

(d) Further data have been collected on the life histories of other bores in particular of *Xylotrechus smei* and *Sphaerotrypes siwalikensis*. In connection with the biology of the latter species a revision has been undertaken of the whole genus ; preliminary conclusions were published in Indian Forester, Volume XLVII, pages 514-518, "Bark beetles of the Genus *Sphaerotrypes*."

INSECTS OR TEAK :—(a) *The Beehole Borer*.—The preliminary note on the ecology and economic status of the beehole borer *Duomitus ceramicus* appeared during the year (Indian Forest Records, Volume VIII, Part III).

On October 17th, 1921, Mr. J. M. D. Mackenzie, I.F.S., was appointed to the post of Divisional Forest Entomologist to investigate the problem of the beehole borer, a programme of operations was drawn up and during October to December a tour was made with the Forest Zoologist in the Northern Shan States, North Toungoo, Insein and West Salween divisions, Burma. This officer reverted from the Research Institute strength to the provincial cadre on 29th January 1922, but continued on special enquiry, *vide* report of the Divisional Forest Entomologist in the Burma section of this Chapter.

(b) *Other Pests*.—A compilation of the available information on teak pests has been started, but completion of the work is postponed until Divisional Forest Entomologists are available.

MISCELLANEOUS PESTS :—*The Shot-hole borers of the evergreens.*

A tour was made in May and June 1921 in Sibsagar and Lakhimpur divisions, Assam, to study forest insects conditions in mixed evergreen forests. The dominant feature of the borer fauna of felled timber is the numerical superiority of the shothole borers (*Platypodidae* and *Xyleborinae*), which are rich in species of Malayan facies, the majority collected being new to India or undescribed. The species are markedly polyphagous, some apparently confined to natural orders, but most indiscriminate feeders. In the evergreens, trees like *Vatica lanceaefolia* and *Dipterocarpus pilosus*, are attacked in addition to the local series by almost all the species of shothole borers occurring in *Shorea robusta* in Bengal and North-West Assam. Passing into the drier dipterocarp forests with fewer tree species in admixture, e.g., *sal* or *indaing*, the shothole borer fauna grows sparse and species like *Diapus furtivus* and *Platypus solidus* (which in the moist evergreens are less abundant) become the dominant members of the association. For these reasons in an investigation directed to the control of shothole borers of valuable timbers in evergreen forest, one must consider also the unmarketable or weed species of trees, often the preferred hosts.

The borers of timber under seasoning.—Work was continued on the liability of timber under different methods of seasoning to attack by borers, and on the species of insects responsible for the various forms of damage. In collaboration with the Timber Seasoning Officer a summary of results has been prepared for the press. As far as the reduction of borer-damage is concerned empirical methods of investigation may for certain conditions give practical results, but for many species of timbers the prevention of insect-attack cannot be assured without specific determination of the optimum period for felling or girdling. In refractory cases, where seasoning in the unbarked log is essential, there are indications that by encouraging the attack of minor sap-wood borers immunity from damage by large heartwood borers can be secured.

The borers of living trees.—The general survey made on dead trees of the variety and extent of borer injury has yielded the unexpected information that the living tree is commonly subject to attack by insects of the beehole borer type, which damage the timber without seriously affecting the vitality of the tree. Recognition of this type of damage permits a correct appreciation of the value of empirical methods of seasoning.

Insect pests of Afforestation.—A tour was made in September 1921 in the Afforestation Division, U. P. to determine the pests of young *Acacia arabica*, *Dalbergia Sissoo*, etc. Plantations of this type do not appear to be subject to serious damage except under epidemic conditions, and this can be controlled by general principles.

The Parasites of Scale-insects and wood-borers.—Dr. Waterston's paper describing new species of Chalcidoidea parasites on pests of

chir, *sal*, *toon*, *sundri*, etc., was issued after the close of the year as Indian Forest Record, Volume IX, Part II.

Insectary.—Some 1,200 specimens for the study of miscellaneous pests have been received in the Insectary during the year. Additions to the Museum are mainly examples of borer-damage to various timbers.

2. DIVISIONAL FOREST ENTOMOLOGIST.

(See under *Burma*).

3. SYSTEMATIC ENTOMOLOGIST.

Dr. M. Cameron, M.D., etc.

The Insect Collection.—The work in this section has resulted in the identification and addition of 672 species of insects not previously represented in the collection. Forty-three of these species are new to science, and are represented either by types or cotypes. The specialists assisting in identification work are Messrs. Andrewes, Arrow, Blair, Corporaal, Marshall, Flentiaux, D'Orchymont, Kleine, Winn Sanipson, for *Coloptera*; Morice, Waterston, Rohwer, Friese for *Hymenoptera*; Meyrick for *Microlepidoptera*; Fraser for *Odonata*; Brunnetti, Senior White, Ricardo for *Diptera* whilst promise of assistance is given by M. Esben-Petersen for *Neuroptera* and Prof. Silvestri for *Isoptera*. To these specialists 2,739 specimens were despatched during the year, of which 1,478 were named and returned. Dr. Cameron in addition to routine work in all groups has given special attention to *Rhynchota*, and to species of economic importance connected with investigations or departmental enquiries. Mr. Beeson has been working on the *Scolytidae*.

The accumulation of identified material has necessitated expansion and rearrangement of the collection on a large scale; for this purpose over 400 store boxes and 13 twenty drawer cabinets were acquired. In all 7,460 species are now accommodated, including 556 novelties out of the 672 recorded during the year, but a very large amount of named duplicates, and an unestimated mass of unnamed material remains to be dealt with, when funds are sanctioned for the purchase of store cabinets. The building up of the insect collection has made unprecedented progress since the establishment of this section, but future acceleration depends on the continued regular supply of store cabinets.

Publication.—The majority of the descriptions of new species have been published by their authors in the entomological literature of England, France and United States, but arrangements are being made for the issue of systematic work by foreign authors in the Records of the Research Institute.

Beeson, C. F. C. The Beehole Borer of Teak (*Duomitus ceramicus*, Wlk.) Indian Forest Records.

- Beeson, C. F. C. Dark beetles of genus *Sphaerotrypes*,
Indian Forester.
- Beeson, C. F. C. Recent Work in Forest Entomology,
Proc. Fourth Entomological Meeting,
1921, pages 182-183.
- Beeson, C. F. C. Notes on the Imperial Entomological
Conference, London, *Loc. cit.*,
pages 383-386.
- Beeson, C. F. C. The Food Plants of Indian Forest Insects,
Part VI (*Scarabaeidae*) Indian
Forester, June 1921, pages 247-252.
- Mackenzie, J. M. D. Some notes on forest insect pests in
Burma, (*Indian Forester*, Volume
XLVII, pages 309-317).

Burma.

Mr. J. M. D. Mackenzie, Deputy Conservator of Forests, has been on special duty in connection with the investigation of the beehole borer in teak (*Duomitus ceramicus*, Wlk.). From October 17th 1921 to January 28th, 1922; he was attached as Divisional Forest Entomologist, Burma, to the Forest Research Institute, Dehra Dun, and from then to the end of the year, he reverted to the provincial cadre, and was placed on special duty, attached to the office of the Chief Conservator of Forests. On March 21st he went to Dehra Dun to work up the technique of the investigation at the Forest Research Institute, where there are specialists, collections, and literature available.

2. In the course of 5 months field work 1798/bee-holes were found and mostly dated, in 292 trees; the highest incidence found was 187, and 106.1 bee-holes per tree per 100 years in Pyonochaung Res. N. Toungoo Division, the lowest nil in the W. Salween Division (Kyundaung Res.) the Prome plantation and 5 year old plantation in Pile Res., Katha. The average for all trees analysed is 31 bee-holes per tree per 100 years.

3. The data so far collected are insufficient to do more than indicate lines of investigations which may yield good results, and much more work will have to be done before any definite conclusion can be reached. The effects of fire-protection and admixture with other species are matters to be specially looked into in the coming year. An unexpectedly low incidence in an Insein plantation with a large admixture of other species, indicates that this may afford some check; three areas in Pyonochaung Res., N. Toungoo Division, half a mile away from each other, of which two had been until recently, fire protected and the other not, gave much the lowest incidence for the unprotected area, though all three areas showed approximately parallel rises and falls.

4. The largest trees in any area were often noticed to be comparatively lightly attacked. In some cases they were fire scarred, and their size was fictitious, due to a swollen base; but the question whether the actual vigour of such trees enables them to stop an attack requires looking into.

5. An area of natural forest in Pile Res. Katha, in which trees up to 122 years old were analysed shewed two distinct rises—one in 1860-70 and one (much the greater) in 1890-1900, while the general trend of the curve shews that the degree of infestation in the area has been steadily increasing from 1840. Generally speaking, Okkyi Res., in Bhamo, where younger trees had been formerly analysed, bore this out, but more analyses of natural forest trees are required.

6. Woodpeckers have been found to be a considerable factor in control in young plantations, up to 15 or 20 years old, after which their influence declines as the size of the tree becomes such that except near the top the birds cannot reach the bore hole or cannot locate it. This applies to larvae which are nearly full grown: the effect on the younger stages, (i.e., from the egg up to October or November) remains to be looked into. The double hole—one into the sapwood chamber and one 4" to 6" higher up, into the boring is typical of a woodpecker's attack on *Duomitus* after October.

7. An ichneumonid parasite, a compoplegid near *Angitia*, was found to have parasitised a sufficiently large proportion of *Duomitus* larvae in Katha to be well worth further investigation, and this will be taken in hand. Insectaries are to be made, probably in Katha and Tharrawaddy Divisions.

8. A live larva found in February in a tree felled in August, in Pinyinmana Division, died on April 1st indicating that from August fellings, larvae are probably unable to emerge as moths; there were indications that November fellings might not bring about this result, as larvae were found almost fully fed in this month.

9. Beeholes were found to be numerous in *Cassia Fistula* (ngu) but were made by another species of *Duomitus*, probably *leuconotus*. They were also found in *Callicarpa macrophylla* (dawng satpya), from which no larvae were obtained. This tree is varbenaceous, and very closely allied to teak; if it proves to be an alternative host, its removal from plantations is indicated, while the possibility of using small plantations of the species as trap areas requires investigation.

10. In the course of analysis, damage by other insects was noted for information and use on future investigations. At least one species of *Laniid* (*Nupserha* ? *variabilis*, Gahan) was found to make galls in a creeper, *Thunbergia grandiflora* and to pupate in small borings in teak, *yemane* and *ywe* (*Gmelina arborea* and *Spondias mangifera*): probably at least 2 other species have similar habits.

11. *Haplohammus cervinus* (Lamiidae) was found causing swellings in young plantations in Tharrawaddy, Katha and Mu Divisions a *Sagra* (Chrysomelidae) was taken from an occluded boring in Tharrawaddy and 'a *Caloclytus* from a short pupating gallery both in teak. Arbelids (? *Arbela tetraonis*) were found in teak, *pyngado*, *yndaik* (*Dalbergia cultrata*) and *ankehinsa* (*Diospyros chretoioides*): 4.

12. *Platypus soldius*, *Xyleborus interjectus*, *Xyleborus submarginatus* and *Xyleborus velatus* (shot-hole borers) were taken from dead portions of live teak.

13. Several teak in natural forest in the Minbu Division died last year, and the only cause to which their death seems to be due was defoliation in October—November, and the strain caused by putting out a second crop of leaves, combined with the shortness of the period during which that crop of foliage can function.

14. The *toon* shoot borer was found wherever *Cedrela Toona* (*thitkada*) had been put into plantations, notably Katha and W. Salween Divisions.

Central Provinces.

Experimental work in connection with lac infection was again carried on. The dates of swarming of larvae have been fairly definitely settled for the Raipur division.

Schleichera trijuga (kusum) .. { Middle of July.
Latter half of January.

Butea frondosa (palas) etc. .. First-half of July.

Zizyphus Jujuba (ber) ... First half of November.

Whenever lac work is undertaken it is most important that these dates should be accurately known. In July 1921 about 130 *kusum* trees which had been pruned in August 1920 were inoculated with locally bought lac. The results were not very good. The reason why the results were not good have since become obvious. The hot weather of 1921 was very severe; the brood was poor, numbers of the mother insects having died, the brood was cut too early because the date of swarming was not accurately known. The crop from these trees was only a little more in weight than the brood used to infect them. In January 1922 roughly 2,000 *kusum* trees, pollarded in February 1921, were inoculated with lac. The mistakes made in June-July were again repeated but as the work was heavier it was more extended in time. It was found that inoculation carried out in December was a complete failure, in early January gave poor results but trees infected late in January give every sign of bearing an excellent crop in June-July 1922. Such trees are covered with

dense masses of lac and now appear very promising. The conclusions drawn are :—

- (1) The dates of swarming must be fairly accurately known.
- (2) Brood cut within a fortnight of such dates is likely to give good results. Inoculation can go on for about a week after the larvae have begun to swarm and may still give good results.
- (3) The best results are obtained with brood cut just as the larvae are about to swarm. In small scale work it is therefore best to wait until the brood is actually swarming. In large scale work operations should commence a fortnight earlier.

3. Experiments of a similar nature were carried out on *ber*, (*Zizyphus Jujuba*), *palas*, (*Butea frondosa*) and *ghont* (*Zizyphus xylopyra*) and gave similar results. The success obtained with *ber* was at first very promising and trees inoculated in November "took" very well. The larvae spread all over the young shoots and developed normally. It has been discovered however that heavy mortality occurred in March. The reason appears to be that natural *ber* in this district occurs in dry places. In such localities the commencement of physiological action in the tree after the cold weather period is delayed until May-June. The females, fertilised in February—March and demanding large supplies of food material, do not get it at that time and therefore die. It would seem advisable to reserve *ber* for the cold weather crop and maintain the brood during the hot weather on *palas*.

4. Experiments on pollarding or pruning were continued. The results are so far as follows.

Kusum must be pruned one to two years before inoculation with lac, the period depending on the locality. In some places strong healthy shoots are produced in one year, in others, particularly in dry places, 1½ to 2 years is necessary. *Kusum* trees growing in dense jungle require clearing and pollarding. It is not yet considered definitely proved whether bushy crowned trees growing in the open give better results by pollarding or not.

Ber.—It is considered to be definitely proved that *ber* produces fine strong shoots fit to be inoculated with lac within six months of pollarding.

Ghont.—No definite results yet.

Palas.—No definite results yet but it seems probable that good results will be obtained by pollarding one year before inoculation.

The mortality of bison, deer, monkeys, squirrels and birds in the 1921 hot weather in South Chanda Division was very high. It will be interesting to see if the abnormal casualties amongst birds have any resultant striking effect on the forest insect pests.

Beyond the annual appearance of the teak defoliator there is nothing further to report.

CHAPTER VI.

FOREST CHEMISTRY.

Central Institute.

The following is a list of the subjects sanctioned for investigation in the Chemical Branch of the Forest Research Institute during the period under report :—

1. Gum, Resins, Oleo-resins and Essential Oils.—

(1) General study of essential oils.

(2) General study of gums, resins, oleo-resins, gum oleo-resins and wood oil and natural varnishes.

2. Miscellaneous Enquiries.—

(1) General enquiry into oil seeds and their uses.

(2) Investigation into Indian turpentines.

3. General investigation into the nature and value of dyes obtainable from woods, barks, fruits, flowers and leaves.

A. Essential Oils.—During the past year a large number of essential oils have been examined and the results are briefly summarised below.

(1) *Pinus longifolia*.—The constitution of sesquiterpene *longifolene* is being actively investigated and interesting results have been obtained. Owing to the difficulty necessarily entailed in an investigation of this sort it will probably be some time before any conclusions can be drawn from the experimental data.

Experiments on the synthesis of *d-carene* have been continued.

It may be of interest to mention that the presence of *d-carene* can be used as a means of determining whether a turpentine is of Indian origin, i.e., obtained from the oleo-resin of *P. longifolia*. Advantage was taken of this in an analysis of a sample of turpentine sent from Bareilly which had been stated to emanate from America. It was conclusively proved to be an Indian turpentine.

(2) *Pinus excelsa*.—A sample of the turpentine from the oleo-resin of *P. excelsa* has been thoroughly examined. This turpentine contains *d-d*-pinene, *d*-terpineol, a bicyclic sesquiterpene and *n*-undecane. The presence of the last named paraffin hydrocarbon is very interesting. A paper embodying the results of this investigation is in the press.

(3) *Zanthoxylum alatum*.—The seeds of *Z. alatum* yield an oil consisting mainly of phellandrene. It is of no commercial value. The Forest Research Institute is grateful to Colonel C. R. Johnson of Abbottabad for supplying the seeds.

(4) *Zanthoxylum Budrunga*.—The seeds yield an oil consisting almost solely of *l*-sabinene, a terpene not previously found in nature. A sample of the oil is being valued in England.

(5) *Blumea Malcolmii*.—A quantity of the grass of *Blumea Malcolmii* was distilled at Belgaum in November. The oil was found to be of considerable interest and consisted essentially of *d*-carvotanacetone and *l*-tetrahydrocarnone.

(6) *Andropogon Jurarancusa*.—Two samples of this oil have been examined, one from a grass grown in the Hazara District and one from a grass grown in Sind. Although botanically the grasses are identical the two oils are very different in properties. The Hazara grass yields an oil containing over 70 per cent. of a ketone *d*-piperitone (a ketone also present in the oil from *Eucalyptus divers*). The constitution of this ketone was definitely established. The oil from the Sind grass also contains this ketone but only to the extent of 44 per cent. It appears to resemble closely the oil from *C. sennarogensis*, Chiov. from the Soudan.

(7) *Camphor*.—The experimental work in camphor has been completed and a paper embodying the results of the investigation has been prepared for publication.

(8) *Abies Pindrow*, Spach.—A sample of the oil from the leaves of *Abies Pindrow*, Spach was received from Colonel C. R. Johnson of Abbottabad. The oil consists mainly of α - and β -Pinene. A paper giving the results of this investigation was issued after the close of the year.

Fixed oils.—The oils and fats from seeds of the following have been examined :—*Chloroxylon Swietenia*, *Calophyllum Wightianum*, *Shorea robusta*, *Mimusops Elengi*, *Garcinia Cambogia*. A paper embodying the results of this investigation was issued after the close of the year.

Vegetable Dyestuffs.—The experiments on the synthesis of morindone were not successful but some new derivatives of anthraquinone were prepared and the results have been published.

The experiments on rottlerin have been suspended owing to the pressure of other work.

Medical Plant Products.—The experiments on the analysis of various samples of *Artemisia maritima* from Kashmir have been completed and appear to indicate that it would be profitable to use the Kashmir plant as a source of santonin. The results of an analysis made in London by Professor Greenish have confirmed the Dehra figures.

Miscellaneous.—The usual number of routine analyses for Forest Officers have been made and do not call for comment.

At the present time the machinery for the commercial valuation of any products prepared in these laboratories is most deficient. Owing to the kindness of Professor W. H. Perkin, F.R.S., of the

University of Oxford a number of essential oils have been valued but unless the procedure is officially recognised it obviously cannot prove satisfactory. The Imperial Institute has not been made use of as it has always in the past proved useless.

Mr. Gopal Rau visited Belgaum in November and distilled a quantity of the oil from *Blumea Malcolmii*. The Forest Chemist visited Madras in February and attended the meeting of the Science Congress.

A complete record of the analytical work done in the Laboratory has been maintained.

The Branch has received the greatest assistance both from other Research Officers in the Institute and from the Forest Officers of the Department. The Forest Chemist wishes to thank them as without their cordial help progress would be very much hindered; he wishes and specially to express his thanks to Mr. Robertson, Officer-in-Charge, Minor Forest Products, without whose able assistance much work could not have been undertaken.

The Laboratory equipment has been much improved during the year.

CHAPTER VII.

FOREST PUBLICATIONS.

	Title.	Author.	Date of issue.
	FOREST RECORDS.		
	<i>Issued.</i>		
1.	Report on Lac and Shellac . . .	H. A. F. Lindsay and C. M. Hailow.	May 1921.
2	Note on the Regeneration of Sal Forests.	R. S. Holo . . .	July 1921
3	Note on the Beehole Borer of Teak	C. F. C. Beeson . .	December 1921
4	Notes on Artificial Regeneration in Bengal.	H. O. Shebbencare, A. K. Glasen, L. E. S. Tengue and F. T. Russell.	January 1922.
	<i>In Press.</i>		
5	The Essential Oil from the leaves of <i>Abies Pindrow</i> , Spach.	J. L. Simonsen . . .	(Issued in June 1922.)
6	Note on Chalcidoiden . . .	J. Waterson . . .	(Issued in August 1922.)

—	Title.	Author.	Date of issue.
7	Results of Antiseptic Treatment of Sleepers.	R. S. Pearson .	(Issued in August 1922.)
8	Notes on Oils and Fats from the Seeds of Indian Forest Trees.	Gopal Ran and J. L. Simonson.	(Issued in September 1922.)
9	Note on the Constituents of some Indian Essential Oils.	J. L. Simonson and Gopal Ran.	(Issued in November 1922.)
FOREST BULLETINS.			
<i>Issued.</i>			
10	Note on Weights of Seeds . . .	S. H. Howard .	April 1921.
11	Note on Halda (<i>Adina cordifolia</i>).	C. E. O. Cox .	September 1921.
12	Note on <i>Odina Wodier</i> . . .	Do. . .	Do.
13	Note on Samal or Cotton Wood (<i>Bombax malabaricum</i>).	Do. . .	Do.
14	Note on Rate of Growth of Bengal Sal.	S. H. Howard .	Do.
15	Note on the Miscellaneous Forests of the Kumaon Bhabar.	E. A. Smythies .	Do.
<i>In Press.</i>			
16	Volume Tables and Form Factors for Sal.	S. H. Howard .	(Issued in May 1922.)
17	Note on Kindal (<i>Terminalia paniculata</i>).	R. S. Pearson .	(In final print.)
18	Note on Thingan (<i>Hopsea odorata</i>).	A. Rodger .	(Issued in October 1922.)
19	Note on Gurtjun or "Kanyin" .	W. A. Robertson .	(Issued in November 1922.)
20	Note on Classification of Thinnings.	.....	Do.
21	Note on an Investigation of certain factors concerning the Resin tapping industry in <i>Pians longifolia</i> .	H. G. Champion: .	
OTHER PUBLICATIONS.			
<i>Issued.</i>			
22	Code for the Collection and Tabulation of Statistical Data.	S. H. Howard .	July 1921.
23	Code for the Collection and Tabulation of Statistical Data. Appendices.	Do. . .	Do.
24	Progress Report of the Forest College, Dohrn Dun, for 1920-21.	.....	December 1921.

	Title.	Author.	Date of issue.
	<i>In Press.</i>		
25	Progress Report of Forest Research Work in India, 1920-21.	.....	(Issued in June 1922.)
26	Flora of the Andamans	C. E. Parkinson	.....
27	Mechanical, Physical and Structural Properties of Wood Grown in India, Project No. 1.	L. N. Seaman	(Issued in September 1922.)
28	Note on the methods of preparing volume and money yield tables of teak woods and volume and form factor tables for teak trees.	R. Bourne	(In final print.)

Contributed to Periodicals.

(1) Note on the Essential Oil from the leaves of *Skimmia Laureola*, by J. L. Simonsen. (Journ. Soc. Chem. 1921 XL 126.)

(2) Synthesis of 1 : 6-Dihydroxy-2-Methyl Anthraquinone, by J. L. Simonsen and M. Gopal Rau. (Trans. Chem. Soc. 1921. 119 1339.)

(3) The Essential Oil from *Andropogon Jwarancusa*, Jones, and the Constitution of Piperitone, by J. L. Simonsen (Trans. Chem. Soc. 1921. 119. 1644.)

(4) Sautonin, by J. L. Simonsen. (Journ. Ind. Industries and Labour, 1921. I. Pt. 4.)

Burma.

In addition to the Burma Forest Bulletins mentioned in last years reports the following have been published:-

No. 4. Extracts from the Silvicultural Section of Divisional Annual Reports, 1920-21.

No. 5. Note on a short tour in Northern Bengal.

United Provinces.

The "Forest Pocket Book" was published during the year and a reprint of Mr. Benskin's "Afforestation in the United Provinces" is in the press. A certain amount of miscellaneous literature has been supplied to newspapers and periodicals.

APPENDIX I.

Administration Report of the Forest Research Institute and College for the year 1921-22 (1st April 1921 to 31st March 1922).

Administration.—The post of President, Forest Research Institute and College was held by Mr. W. F. Perrée, C.I.E., Chief Conservator of Forests throughout the year.

The names of the officers who held charge of the various branches are given below :—

Branch of Forest Research Institute.	MONTH AND DATE.		Name of Officer in charge of branch.
	From	To	
Silviculture . .	1st April 1921 .	17th February 1922.	Mr. S. H. Horrad, B.A., Deputy Conservator of Forests, United Provinces.
	18th February 1922.	31st March 1922	Mr. H. Trotter, M.C., Deputy Conservator of Forests, Burma.
Forest Botany . .	1st April 1921 .	31st March 1922	Mr. R. S. Hole, C.I.E., F.C.H., F.L.S., F.E.S., Conservator of Forests, India list.
Forest Economy . .	1st April 1921 .	31st March 1922	Mr. R. S. Pearson, C.I.E., F.L.S., Officiating Conservator of Forests, Bombay.
Forest Zoology . .	1st April 1921 .	31st March 1922	Mr. C. F. C. Beeson, M.A., I.F.S., F.E.S., Deputy Conservator of Forests, Punjab.
Forest Chemistry	1st April 1921 .	31st March 1922	Dr. J. L. Simonsen, D.Sc., T.L.C., F.A.S.B.

APPENDIX II.

Financial.

The expenditure of the past two years is compared below :—

	EXPENDITURE DURING THE YEAR.		Difference + or —.
	1920-21 (9 months, July 1920 to March 1921).	1921-22 (12 months, 1st April 1921 to 31st March 1922).	
	Rs.	Rs.	Rs.
AVI Stores, Tools and Plant ...	26,906	1,11,417	+84,511
AVII Building, etc. ...	2,852	6,841	+ 3,989
AIX Miscellaneous ...	81,526	69,069	+87,543
BIa Conservators ...	15,011	57,000	+41,419
BIb Superior Officers ...	99,244	1,84,803	+85,618
BIc Subordinate Forest and Depot Establish- ment.	3,379	3,364	— 15
BI d Office Establishment ...	34,081	58,672	+24,591
BIe Deputation and Special Allowances ...	13,240	23,500	+ 9,254
BI f Compensation for dearthness of provisions	995	— 4	— 999
BII Travelling Allowances ...	19,087	31,095	+12,008
BIII Contingencies ...	25,038	44,561	+19,523
TOTAL ...	2,71,996	5,89,468	+3,17,472

The increase under AVI is due to the purchase of machinery for the Economic Branch consequent on its expansion.

The increase under AVII is due to the electric installation in the Wood Workshops of the Economic Branch, additions and repairs to the godowns of the Economic Branch, construction of a motor shed at Gladysville and for making certain alterations to the Botanical Museum building.

The increase under AIX is due to larger expenditure having been incurred on experiments by the Forest Economist and to the purchase of more Chemicals for the Forest Chemist.

The increase under BIa is due to the promotion of Messrs. Hole and Pearson to the class of Conservators.

The increase under BIb is due to the appointment of Experts and Upper Grade Assistants in the various branches of the Institute.

The decrease under BId is nominal and requires no explanation.

The increase under BId is due to the figures of 1920-21 representing 9 months against 12 months for 1921-22 and to the appointment of extra establishment.

The increase under BId is due to the payment of duty allowance of Systematic Botanist and Upper Grade Assistants for 12 months instead of for a shorter period in the previous year.

The decrease under BId is due to the abolition of compensation for dearness of provisions.

The increase under BII is due to extensive touring of Research Officers owing to the expansion of the Institute.

The increase under BIII is due to the purchase of back numbers of certain German works of reference for the Chemical Branch.

W. F. PERRÉE,

President,

Forest Research Institute and College.

APPENDIX III.

Annual Form No. 24.

FOREST DEPARTMENT, INDIA, FOREST RESEARCH INSTITUTE DIVISIONS.

Summary of Revenue of the different Divisions during 1921-22.

BUDGET HEADS.	President.	Agriculturist.	Forest Botanist.	Forest Zoologist.	Forest Economist.	Forest Chemist.	TOTAL.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
REVENUE.							
I.—TIMBER AND OTHER PRODUCTS REMOVED FROM THE FOREST BY GOVERNMENT AGENCY—	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
(a) Timber	..	..	..	..	..	..	..
(b) Firewood and charcoal.	..	..	..	..	..	..	..
(c) Bamboo	..	..	..	..	..	..	..
(d) Sandal-wood.	..	..	..	..	..	..	..
(e) Gums and other minor produce.	..	..	..	..	..	..	..
TOTAL I	..	..	..	..	..	..	..
II.—TIMBER AND OTHER PRODUCTS REMOVED FROM THE FOREST BY COMMUNITIES OR INDIVIDUALS—							
(a) Timber	..	..	..	..	..	..	..
(b) Firewood and charcoal.	..	..	..	..	..	..	..
(c) Bamboo	..	..	..	..	..	..	..
(d) Gums and fodder gums.	..	..	..	..	..	..	..
(e) Other minor produce.	..	..	..	..	..	..	..
(f) Other items	..	..	..	..	..	..	..
(g) Commutation fees.	..	..	..	..	..	..	..
TOTAL II	..	..	..	..	..	..	..
III.—DEERS AND WILD BIRD AND CONTINGENT FOR THE PRODUCE.							
TOTAL III	..	..	..	..	..	..	..
IV.—REVENUE FROM FORESTS, NOT MANAGED BY GOVERNMENT—							
(a) Duty on foreign timber and other forest produce.	..	..	..	..	..	..	..
(b) Revenue from shared and private forests.	..	..	..	..	..	..	..
TOTAL IV	..	..	..	..	..	..	..
V.—MISCELLANEOUS—							
(a) Fines and forfeitures.	..	..	..	..	..	..	..
(b) Refunds	10,651 15 0	200 0 0	82 10 6	4 8 3	212 6 0	4 0 7	216 7 1
(c) Other sources	..	..	..	..	634 0 1	175 9 3	17,797 11 6
TOTAL V	..	..	..	..	..	..	..
GRAND TOTAL REVENUE.	10,651 15 6	200 0 0	82 10 6	4 8 3	850 6 7	180 0 10	12,014 2 7

APPENDIX III—contd.

Annual Form No. 24—contd.

FOREST DEPARTMENT, INDIA, FOREST RESEARCH INSTITUTE DIVISIONS.

Summary of Revenue of the different Divisions during 1921-22.

BUDGET HEADS.	President.	Silviculturists.	Forest Botanist.	Forest Zoologist.	Forest Entomologist.	Forest Chemist.	TOTAL.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EXPENDITURE.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
A.—Conservancy and Works.							
I.—TIMBER AND OTHER PRODUCTS REMOVED FROM THE FOREST BY GOVERNMENT AGENCIES—							
(a) Timber . .	..	000	000	000	000	00	000
(b) Firewood and charcoal.	000	000	000	000	000	000	000
(c) Bamboo . .	000	000	000	000	000	000	000
(d) Sandal-wood	000	000	000	000	000	00	000
(e) Gums and other minor produce	..	000	000	000	000	000	000
TOTAL A. I.	..	000	000	00	000	000	000
II.—TIMBER AND OTHER PRODUCTS REMOVED FROM THE FOREST BY CONSUMERS OR FURNISHERS—							
TOTAL A. II.					00	00	000
III.—DRIFT AND WAX WOOD AND CONTIGUOUS FOREST PRODUCE—							
TOTAL A. III.	..	00	00	000	00	00	000
IV.—REVENUE FROM FOREST NOT MANAGED BY GOVERNMENT—	000	000	000	000	000	000	000
(a) Duty on foreign timber and other forest produce.	000	000	000	000	000	00	000
(b) Revenue from shared and private forests	000	000	000	000	000	00	000
TOTAL A. IV.	000	000	000	000	000	000	000
V.—RENT OF ENCLOSED FOREST AND PAYMENTS TO SHAREHOLDERS IN FORESTS MANAGED BY GOVERNMENT—							
TOTAL A. V.	000	000	000	00	000	000	000

APPENDIX III—contd.

Annual Form No. 21—contd.

FOREST DEPARTMENT, INDIA, FOREST RESEARCH INSTITUTE DIVISION.

Summary of Expenditure of the different Divisions during 1921-22.

BUDGET HEADS.	Forest.	Experimental	Forest P. and S.	Forest P. and S.	Forest Economic.	Forest Chemical.	TOTAL.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VI.—LITERATURE, PRINTING, AND PUBLICATIONS.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
(a) Purchase of books, etc.	...	...	...	...	...	...	...
(b) Printing and publication of literature.	...	...	...	...	...	...	...
(c) Purchase of printing and publication.	2,112 5 0	1,325 1 0	1,214 5 10	10,433 13 3	62,403 1 3	7,823 0 5	1,11,416 11 3
TOTAL A. VI.	2,112 5 0	1,325 1 0	1,214 5 10	10,433 13 3	62,403 1 3	7,823 0 5	1,11,416 11 3
VII.—COMMISSIONS AND DEEDS.							
(a) Bonds and deeds.	...	...	...	...	...	...	...
(b) Buildings.	6,210 0 3	...	...	...	...	...	6,210 0 3
(c) Other works.	371 1 7	...	273 5 0	...	...	...	636 7 4
TOTAL A. VII.	6,581 10 10	...	273 5 0	...	...	...	6,854 10 7
VIII.—ORGANIZATION, IMPROVEMENT, AND REGENERATION OF FORESTS.							
(a) Demarcation.	...	...	...	...	...	...	...
(b) Cost of Forest Settlements, compensation for land and rights.	...	...	...	...	...	...	...
(c) Survey.	...	...	...	...	...	...	...
(d) Working plans.	...	...	...	...	...	...	...
(e) Fencing and planting.	...	...	...	...	...	...	...
(f) Protection from fire.	...	...	...	...	...	...	...
(g) Other works.	...	...	...	...	...	...	...
TOTAL A. VIII.	...	...	...	...	...	...	...
IX.—MISCELLANEOUS.							
(a) Law Charges.	...	...	...	...	...	...	...
(b) Other Charges.	3,774 15 7	4,423 14 11	1,103 15 0	3,255 15 3	31,705 0 1	10,216 12 2	43,266 15 9
TOTAL A. IX.	3,774 15 7	4,423 14 11	1,103 15 0	3,255 15 3	31,705 0 1	10,216 12 2	43,266 15 9
TOTAL A.—CONVEYANCE, TRAVEL AND WORKS.	12,823 15 6	6,753 0 5	2,070 11 4	18,700 12 0	1,10,363 7 4	27,033 12 7	1,67,323 11 7
B.—ESTABLISHMENTS.							
I.—SUPERVISORY.							
(a) Officers and men.	15,770 0 0	...	22,000 0 0	...	10,810 5 2	...	37,000 5 2
(b) Superior Officers.	...	14,075 1 5	6,500 0 0	15,833 14 1	94,347 13 6	15,201 9 2	1,36,223 0 9
(c) Voted.	6,400 0 0	3,241 0 0	6,400 0 0	3,200 0 0	672 0 3	5,834 8 1	28,638 12 4
(d) Subordinate forest and dep't estab-lishments.	...	...	...	2,375 0 0	635 12 11	...	3,369 12 11
(e) Office estab-lishments.	12,100 5 3	6,530 0 5	7,231 13 8	9,205 2 1	12,775 12 10	6,810 3 7	83,972 8 10

APPENDIX IV.

Annual Form No. 27.

FOREST DEPARTMENT, INDIA, FOREST RESEARCH INSTITUTE.

Outstandings and Liabilities on account of Contractors and Disbursers for the Forest year 1921-22.

Divisions.	DEPARTMENT DEBTOR.			DEPARTMENT CREDITOR.			BALANCE DUE.		REMARKS.
	Opening balance.	Recoveries in Cash and value of supplies and work done during the year.	Total.	Opening balance.	Payments made during year.	Total.	To Department (Outstandings).	By Department (Liabilities).	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	
Sylviculturist	...	14,648 11 3	14,648 11 3	686 7 0	13,791 8 3	14,780 11 0	171 15 9	...	
Forest Botanist	...	4,276 6 6	4,276 6 6	1,603 1 0	3,818 8 2	5,026 9 8	750 8 2	...	
Forest Zoologist	...	11,021 14 2	11,021 14 2	754 4 1	11,300 0 1	11,611 10 2	612 12 0	...	
Forest Economist.	...	25,451 8 2	25,451 8 2	3,577 4 1	21,300 2 0	27,593 0 7	1,311 11 5	...	
Forest Chemist	...	5,111 1 3	5,111 1 3	61 2 3	5,281 14 4	5,370 1 0	261 18 9	...	
TOTAL	...	60,530 0 4	60,530 0 4	6,273 1 1	54,715 2 4	61,021 6 3	1,961 17 1	...	

M. N. GUPTA,
Assistant Accounts Officer.

CALCUTTA;

The 22nd August 1922.

Certified that the totals of this form as printed in the Forest College and Forest Research Institute Reports for 1921-22 when added together agree with those entered in the Forms for the combined offices as supplied by the Accountant General, Central Revenue, under Article 78 (ii) of the Forest Department Code.

W. F. PERRÉE,
President,
Forest Research Institute and College.

APPENDIX V.

List of Forest Publications issued since the creation of the Forest Research Institute, Dehra Dun.

I.—BULLETINS (OLD SERIES).

	PRICE (exclusive of packing, postage, etc.).	
	Rs.	A. P.
1.—Note on the Bee-Hole Borer of Teak in Burma, by E. P. Stebbing. (<i>Out of print</i>)	0	4 0
2.—Note on the Quetta Borer (<i>Folesthes sartus</i>), by the same author. (<i>Out of print</i>)	0	8 0
3.—Note on the Chilgoza (<i>Pinus Gerardiana</i>) Bark Boring Beetles of Zhob, Baluchistan, by the same author. (<i>Out of print</i>)	0	8 0
4.— <i>Ficus elastica</i> : its natural growth and artificial propagation, with a description of the method of tapping the tree and of the preparation of its rubber for the market, by E. M. Coventry	0	12 0
5.—Notes on a Visit to some European Schools of Forestry, by Stebbing. (<i>Out of print</i>)	2	0 0
6.—Memorandum on Mechanical Tests of some Indian Timbers, by W. H. Everett	0	2 0
7.—Note on the Chilgoza Forests of Zhob and the Takht-i-Saliman, by E. P. Stebbing. (<i>Out of print</i>)	0	12 0
8.—Note on the Life-History of <i>Hyplocrembyx spinicornis</i> (The Singbhun Sal Borer), by the same author	0	9 0
9.—Note on the Influence of Forests on the Storage and Regulation of the Water-Supply, by S. Eardley-Wilmot	1	0 0
10.—Note on the Duki Fig-Tree Borer of Baluchistan. (<i>Batocera rufus</i>), by E. P. Stebbing. (<i>Out of print</i>)	0	7 0
11.—On Some Assam Sal (<i>Shorea robusta</i>) Insect Pests, by the same author	1	10 0

II.—LEAFLETS.

1.—The Sal Bark-Borer (<i>Sphaerotrypes siwalikensis</i> , Steb.), by E. P. Stebbing. (<i>Out of print</i>)	0	4 0
2.—The Teak Defoliator (<i>Hyblosa puera</i> , Cram.), by the same author. (<i>Out of print</i>)	0	2 0
3.—The Teak Leaf-Skeletoniser (<i>Pyrausta machoeralis</i> , Wlk.), by the same author. (<i>Out of print</i>)	0	2 0
4.—The Larger Deodar Bark-Borer (<i>Scolytus major</i> , Steb.), by the same author. (<i>Out of print</i>)	0	4 0
5.—The Blue Pine "Polygraphus" Bark-Borer (<i>Polygraphus major</i> , Steb.), by the same author. (<i>Out of print</i>)	0	3 0

III PAMPHLETS.

1.—Note on Utilization of Khair Forests in Eastern Bengal and Assam, by Purnan Singh. (<i>Out of print</i>)	0	4 0
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APPENDIX V—contd.

III.—PAMPHLETS—contd.

	PRICE (exclusive of packing, postage, etc.).		
	Rs.	A.	P.
2.—The Attack of the Bark-Boring Beetle in the Coniferous Forests in the Simla Catchment Area, by E. P. Stebbing	0	8	0
3.—A Glossary of Forest Technical Terms for use in Indian Forestry, by A. M. F. Caccia. (<i>Revised and issued as Bulletin No. 4, New Series</i>). (<i>Out of print</i>)	0	4	0
4.—Note on Lac and Lac Cultivation, by D. N. Arasia. (<i>Out of print</i>)	0	2	0
5.—Notes on Sal in Bengal by A. L. McIntire. (<i>Out of print</i>)	0	4	0
6.—Note on Forest Reservation in Burma in the Interests of an Endangered Water-Supply, by A. Rodger ..	1	0	0
7.—Note on Andaman Marble Wood or Zebra Wood (<i>Diospyros Kurzii</i> , Hiern.), by R. S. Troup ..	0	4	0
8.—Note on the Collection of Statistical Data relating to the principal Indian Species, by A. M. F. Caccia ..	0	10	0
9.—Tables showing the Progress in Working-Plans in the Provinces outside the Madras and Bombay Presidencies up to 31st December 1908, by the same author	0	10	0
10.—Note on Burmese Leza Wood (<i>Lagerstroemia tomentosa</i> , Presl.), by R. S. Troup	0	2	0
11.—Note on Carallia Wood (<i>Carallia integerrima</i> , DC.), by the same author	0	2	6
12.—Note on Petwun or Trincoyali Wood (<i>Berria Ammonilla</i> , Roxb.), by the same author	0	4	0
13.—Note on Burmese In Wood (<i>Dipterocarpus tuberculatus</i> , Roxb.), by the same author	1	0	0
14.—Note on Burma Padmak (<i>Pliocarpus macrocarpus</i> , Kurz.), by the same author	1	0	0
15.—Note on the Preservation of Bamboos from the attacks of the Bamboo Beetle or "Shot-Borer," by E. P. Stebbing	0	7	0
16.—Note on the Best Season for Coppice Fellings of Teak (<i>Tectona grandis</i>), by R. S. Hole	0	4	0

IV.—BULLETINS (NEW SERIES).

1.—Note on Calorimetric Tests of some Indian Woods, by Puran Singh	0	2	0
2.—Memorandum on Teak Plantations in Burma, by F. A. Leete	0	10	0
3.—Note on the Relative Strength of Natural and Plantation-Grown Teak in Burma, by R. S. Pearson ..	0	4	0
4.—Second Edition of the Glossary of Technical Terms for use in Indian Forestry, by A. M. F. Caccia, revised by R. S. Troup	0	6	0
5.—The Blue Pine Tomious Bark-Borer (<i>Tomious Ribbentropi</i>), by E. P. Stebbing	0	2	0

APPENDIX V—*contd.*IV.—BULLETINS (NEW SERIES)—*contd.*

PRICE
(exclusive of
packing,
postage, etc.).
Rs. A. P.

6.—Memorandum on the Oil-Value of Sandalwood, by Puran Singh	0 2 0
7.—Note on the Chemistry and Trade Forms of Lac, by the same author	0 3 0
8.—Note on some Germination Tests with Sal Seed, (<i>Shorea robusta</i>), by R. S. Troup.....	0 2 0
9.—Note on Resin-Value of <i>Podophyllum Emodi</i> and the best season for collecting it. by Puran Singh ..	0 1 3
10.—Note on the Bark-Boring Beetle attack in the Conifer- ous Forests of the Simla Catchment Area, 1907—1911, by R. S. Hole	0 3 0
11.—A Further Note on some Casuarina Insect Pests of Madras, by V. Subramania Iyer	0 14 0
12.—Note on the Bark-Eating and Root-Boring Beetles of Babul (<i>Acacia arabica</i>), by E. P. Stebbing ..	0 4 0
13.—Note on <i>Ligno Protector</i> as a possible means of prevent- ing timber from splitting while seasoning, by R. S. Pearson	0 5 0
14.—A Further Note on the Relative Strength of Natural and Plantation-Grown Teak in Burma, by the same author	0 3 0
15.—Note on the Technical Properties of Timber with special reference to <i>Cedrela Toona</i> wood while seasoning, by the same author	0 3 0
16.—Note on Gumhar (<i>Gmelina arborea</i> , Roxb.), by A. Rodger	0 3 0
17.—Note on Bija Sal or Vengai (<i>Pterocarpus Marsupium</i> , Roxb.), by the same author	0 4 0
18.—Note on Sain or Saj (<i>Terminalia tomentosa</i> , W. and A.), by the same author	0 5 0
19.—Note on Benteak or Nana Wood (<i>Lagerstroemia lanceo- lata</i> , Wall.), by the same author	0 3 0
20.—Note on Sandan (<i>Ougeinia dalbergioides</i> , Benth.), by the same author	0 3 0
21.—Note on Dhaura Bakli (<i>Anogeissus latifolia</i> , Wall.), by the same author	0 4 0
22.—Note on the Causes and Effects of the Drought of 1907 and 1908 on the Sal Forests of the United Provinces, by R. S. Troup	0 5 0
23.—Note on the Preparation of Indian Forest Floras and Descriptive Lists, by R. S. Hole	0 4 0
24.—Note on Turpentine of <i>Pinus Khasya</i> , <i>Pinus Merkusii</i> and <i>Pinus excelsa</i> , by Puran Singh	0 2 0
25.—Development of the Culms of Grasses, by R. S. Hole ..	0 2 0
26.—Note on the Resin Industry in Kumaun, by E. A. Symthies	1 4 0
27.—Note on Blackwood (<i>Dalbergia latifolia</i> , Roxb.), by E. Benskin	0 4 0
28.—Note on Dhauri (<i>Lagerstroemia parviflora</i> , Roxb.), by the same author	0 4 0
29.—Note on Sundri Timber (<i>Heritiera minor</i> , Lam.), by R. S. Pearson	0 3 0

APPENDIX V—*contd.*IV.—BULLETINS (NEW SERIES)—*concl'd.*

	PRICE (exclusive of packing, postage, etc.).		
	Rs.	A.	P.
30.—The Compilation of Girth Increments from Sample Plot Measurements, by R. S. Troup ..	0	2	0
31.—Note on Indian Sumach (<i>Rhus Cotinus</i> , Linn.), by Puran Singh ..	0	2	0
32.—Note on the Burma Myrabolanus or "Panga fruits" as a Tanning Material, by Puran Singh ..	0	1	0
33.—Note on an Enquiry by the Government of India into the Relation between Forests and Atmospheric and Soil Moisture in India, by M. Hill ..	1	0	0
34.—Note on Red Sanders (<i>Pterocarpus santalinus</i> , Linn. f.), by T. A. Whitehead ..	0	9	0
35.—Note on Babul (<i>Acacia arabica</i> , Willd.), by J. D. Maifland-Kirwan ..	0	5	0
36.—Note on Kokan or Lampatia Timbor (<i>Duabanga sonneratioides</i> , Ham.), by R. S. Pearson ..	0	3	0
37.—Note on the Contraction and Warping which takes place in <i>Pinus longifolia</i> timber while seasoning, by the same author ..	0	11	0
38.—The Construction of Calcareous Opercula by Longicorn Larvæ of the Group <i>Cerambycini</i> (Coleoptera, Cerambycidae), by C. F. C. Beeson ..	0	3	0
39.—Note on Hollong Timber (<i>Dipterocarpus pilosus</i> , Roxb.), by R. S. Pearson ..	0	4	0
40.—Note on Pymna, Ajhar or Jaiul Wood (<i>Lagerstroemia Flos-Reginae</i> , Retz.), by the same author ..	0	6	0
41.—Note on Weights of Seeds, by S. H. Howard ..	0	3	0
42.—Note on Haidu (<i>Adina cordifolia</i> , Hook. f.), by C. E. C. Cox ..	0	8	0
43.—Note on <i>Odina Wodier</i> , Roxb., by the same author ..	0	8	0
44.—Note on Senal or Cotton Wood, by the same author ..	0	10	0
45.—Note on the Miscellaneous Forests of the Kumaon Bhabar, by E. A. Smythies ..	1	0	0
46.—Rate of Growth of Bengal Sal (<i>Shorea robusta</i>), I Quality, by S. H. Howard ..	1	0	0
47.—Volume Tables and Form Factors for Sal (<i>Shorea robusta</i>), by the same author ..	0	6	0
48.—Note on Kundal or Hongal (<i>Terminalia paniculata</i> , W. and A.), by R. S. Pearson ..	0	6	0
49.—Note on Thingan (<i>Hopea odorata</i> , Roxb.), by A. Rodger ..	0	7	0
50.—Note on Gurjun or Kanyin compiled by W. A. Robertson ..	0	4	0

V.—FOREST RECORDS.

Vol. I, Part I.—A Note on the Lao Insect (<i>Tachardia laca</i>), its Life History, Propagation and Collection, by E. P. Stebbing. (Out of print) ..	1	4	0
" Part II.—A Preliminary Note on the Development of the Sal in Volume and in Money Value, by A. M. F. Caccia. (Out of print) ..	1	4	0

APPENDIX V—*contd.*V.—FOREST RECORDS—*contd.*

		PRICE (exclusive of packing, postage, etc.). Rs. A. P.
Vol. I, Part III.—1.	<i>Pterocarpus dalbergioides</i> , Roxb. (Andaman Padouk), by B. B. Osmaston .. .. .	.
" "	2. A Further Note on the Chilgoza Bark- Boring Beetles of Zhob, by E. P. Stebbing and Captain E. H. S. James	1 4 0
" "	3. A Note on the Present Position and Future Prospects of the Cutch Trade in Burma, by R. S. Troup ..	
" "	4. Note on the Manufacture of Ngai Camphor, by Puran Singh. (<i>Out of print</i>)	
" Part IV.—1.	A Chemical Investigation of the Con- stituents of Burmese Varnish (<i>Melanorrhoea usitata</i> , Sap.), by Puran Singh	5
" "	2. The Selection System in Indian Forests as exemplified in Working- Plans based on this system with a short description of some Continental Methods, by A. M. F. Caccia. (<i>Out of print</i>)	1 4 0
Vol. II, Part I.—	Note on some Insect Pests of the Himalayan Oaks (<i>Quercus dilatata</i> and <i>Q. incana</i>), by E. P. Stebbing. (<i>Out of print</i>)	0 6 0
" Part II.—	Note on the Fissibility of some Indian Woods, by R. S. Troup. (<i>Out of print</i>)	1 6 0
" Part III.—1.	Monograph on the Sylviculture of <i>Hardwickia binata</i> (Anjan); by D. O. Witt	3 4 0
" "	2. Notes on Sandal (Germination and Growth of Sandal Seedlings), by M. Rama Rao	
" Part IV.—	Note on Host Plants of the Sandal Tree, by the same author	2 0 0
Vol. III, Part. I.—	Note on some Statistical and other Information regarding the Teak Forests of Burma, by R. S. Troup ..	2 12 0
" Part II.—	Preliminary Note on the Antiseptic Treatment of Timber in India with special reference to Railway Sleepers, by R. S. Pearson	0 14 0
" Part III.—	Report on the Investigation of Bamboos as Material for production of Paper- pulp, by W. Raftt	0 6 0

APPENDIX V—*contd.*V.—FOREST RECORDS—*contd.*

	Price (exclusive of packing, postage, etc.). Rs. A. P.
Vol. III, Part IV.—Note on the Preparation of Tannin Extract with special reference to those prepared from the Bark of Mangrove (<i>Rhizophora mucronata</i>), by Puran Singh	0 7 0
Vol. IV, Part I.—Note on the Distillation and Composition of Turpentine Oil from the Chir Resin and the Clarification of Indian Rosin, by the same author	0 9 9
" Part II.—Note on some new and other Species of Hymenoptera in the Collections of the Zoological Branch of the Forest Research Institute, Dehra Dun, by P. Cameron	0 4 0
" Part III.—Note on Useful Exotics in Indian Forests (No. 1 <i>Proserpis juliflora</i> , DC.), by R. S. Holo	0 4 0
" Part IV.—Note on <i>Albizia Lathamii</i> , by the same author	0 3 0
" Part V.—Note on the Utilization of Bamboo for the Manufacture of Paper-pulp, by R. S. Penison. (2nd Edition)	2 0 0
Vol. V, Part I.—Note on Tea-box Industry in Assam, by the same author. (<i>Out of print</i>)	0 4 0
" Part II.—Note on Blue Gum Plantations of the Nilgiris (<i>Eucalyptus Globulus</i>), by R. S. Troup	1 6 0
" Part III.—Report on the Investigation of Savannah Grasses as Material for Production of Paper-pulp, by W. Raitt. (<i>Out of print</i>)	0 4 0
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" " 2. Note on Ecology of Sal (<i>Shorea robusta</i>), Part II, Seedling Reproduction in Natural Forests and its Improvement, by the same author	1 1 0
" " 3. Note on Ecology of Sal (<i>Shorea robusta</i>), Part III, Soil-aeration and Water-cultures, by the same author	0 8 0
" Part V.—Note on <i>Trametes Pini</i> , by the same author	1 0 0
" Part VI.—Note on a New Species of Forest Grass (<i>Spodiopogon Lacci</i> , Holo), by the same author	0 8 0

APPENDIX V—*contd.*V.—FOREST RECORDS—*contd.*

		PRICE (exclusive of packing, postage, etc.). RS. A. P.
Vol. V, Part VII.—Note on the Economic Uses of Rosha Grass (<i>Cymbopogon Martini</i> , Stapf.), by R. S. Pearson and ..	}	1 8 0
" " Note on the Constants of Indian Geranium Oil (Motia), by Purn Singh. (<i>Out of print</i>) ..		
" Part VIII.—1. Note on the Eucalyptus Oil Industry in the Nilgiris		
" " 2. Note on the Distillation of Geranium Oil in the Nilgiris ..	} By Purn Singh.	1 0 0
" " 3. Note on the Manufacture of Wintergreen Oil in India. (<i>Out of print</i>) ..		
Vol. VI, Part I.—The Life-History of <i>Diaprus furtivus</i> , Sampson, by C. F. C. Beeson ..		0 10 0
" Part II.—Statistics compiled in the Office of the Sylviculturist, Forest Research Institute, Dehra Dun, during 1915-16 ..		1 6 0
" Part III.—A Note on Thitsi (<i>Melanorrhoea usitata</i> , Wall.), with special reference to the Oleo-resin obtained from it, by E. Benskin and A. Rodger. (<i>Out of print</i>) ..		1 2 0
" Part IV.—A Further Note on the Antiseptic Treatment of Timber, recording results obtained from past experiments, by R. S. Pearson ..		3 0 0
" Part V.—Statistics compiled in the Office of the Sylviculturist, Forest Research Institute, Dehra Dun, during 1916-17 ..		0 10 0
" Part VI.—Note on Preparation of Turpentine, Rosin and Gum, from <i>Boswellia serrata</i> (Roxb.), gum-oleo-resin, by R. S. Pearson and Purn Singh ..		0 13 0
Vol. VII, Part I.—Preliminary Note on the Seasoning of some Indian Timbers by Natural Methods, by R. S. Pearson ..		1 0 0
" Part II.—A Further Note on Thitsi (<i>Melanorrhoea usitata</i> , Wall.), with special reference to the Oleo-resin obtained from it in the Lawksawk and Myelat States, Southern Shan States Forest Division, by F. A. Wright ..		0 4 0
" Part III.—Note on <i>Hopca canarensis</i> , Hole, by R. S. Hole ..		0 3 0
" Part IV.—Note on <i>Isora Butterwickii</i> , Hole, by the same author ..		0 3 0

APPENDIX V—*contd.*V.—FOREST RECORDS—*concl'd.*

		Patch (exclusive of packing, postage, etc.). Rs. A. P.		
Vol. VII, Part	V.—Notes on the Larvæ and Life-Histories of Prionine Beetles, Coleoptera, Cerambycidae, Prionine, by C. F. C. Beeson	0	8	0
"	Part VI.—Note on the Mechanical Strength and Seasoning Properties of <i>Shorea robusta</i> (Sal Timber), by R. S. Pearson	0	8	0
"	Part VII.—The Life-History of the Toon Shoot and Fruit Borer, <i>Hypsipyla robusta</i> , Moore (<i>Lepidoptera</i> ; <i>Pyralidae</i> ; <i>Phycitinae</i>) with suggestions for its control, by C. F. C. Beeson	2	4	0
"	Part VIII.—Afforestation of Ravine Lands in the Etawah District, U. P., by E. A. Smythies	2	0	0
Vol. VIII, Part	I.—Report on Lac and Shellac, by H. A. F. Lindsay and C. M. Harlow	2	12	0
"	Part II.—The Regeneration of Sal (<i>Shorea robusta</i>) Forests, by R. S. Hole	2	2	0
"	Part III.—Note on the Bee-Hole Borer of Teak, by C. F. C. Beeson	3	0	0
"	Part IV.—Notes on Artificial Regeneration in Bengal, by A. K. Glasston, P. T. Russell, B. O. Shekheare and L. E. S. Tengner	2	0	0
"	Part V.—Note on the Essential Oil from the leaves of <i>Abies Pindron</i> , Spuch, by J. L. Simonsen. (<i>Out of print</i>)	0	2	0
Vol. IX, Part	I.—Results of Antiseptic Treatment of Sleepers. Note on the Indian Sleeper Market, Record of durability tests on Treated Sleepers and conclusions arrived at therefrom, by R. S. Pearson. (<i>Out of print</i>)	2	0	0
"	Part II.—Note on Chalcidoiden (Mainly bred at Delra Dan from Pests of Sal; Toon, Chir and Sundri), by James Waterston	1	2	0
"	Part III.—Oils and Fats from the Seeds of Indian Forest Trees, Parts I—V, by M. Gopal Rau and J. L. Simonsen. (<i>Out of print</i>)	0	3	0
"	Part IV.—The constituents of some Indian Essential Oils, Parts I—VII, by J. L. Simonsen and M. Gopal Rau	0	6	0

APPENDIX V—*contd.*

VI.—MEMOIRS.

	PRICE (exclusive of packing, postage, etc.).		
	Rs.	A.	P.
Note on the Analysis of Gutch and the Preparation of Pure Gatchin, Vol. I, Part I, Chemistry Series, by Puran Singh. (<i>Out of print</i>)	1	4	0
Note on the Manufacture of Pure Shellac, Vol. I, Part II, Chemistry Series, by the same author. (<i>Out of print</i>)	0	8	0
On Some Undescribed Scolytids of Economic Importance from the Indian Region I, Vol. I, Part I, Zoology Series, by E. P. Stebbing	0	4	0
On Some Undescribed Scolytids of Economic Importance from the Indian Region II, Vol. I, Part II, Zoology Series, by the same author. (<i>Out of print</i>)	0	4	0
Indian Woods and their Uses, Vol. I, Part I, Economy Series, by R. S. Troup	2	12	0
Note on the Prospects of the Match Industry in the Indian Empire, Vol. II, Part I, Economy Series, by the same author	1	12	0
Second Edition of the Monograph on " <i>Lac Insect</i> " (<i>Tachardia lacca</i>), Vol. I, Part III, Zoology Series, by E. P. Stebbing	1	0	0
Note on Some Important Insect Pests of the Himalayan Conifers (Treating of Deodar), Vol. II, Part I, Zoology Series, by E. P. Stebbing. (<i>Out of print</i>)	0	10	0
Note on the Insect Pests of the Chir Pine (<i>Pinus longifolia</i>), Vol. II, Part II, Zoology Series, by the same author	1	14	0
Memoir on Some Indian Forest Grasses and their Ecology, by R. S. Hole	5	8	0
Note on the Life-History of <i>Chermes Himalayensis</i> , Steb., on the Spruce (<i>Picea Morindra</i>) and Silver Fir (<i>Abies Webbiana</i>), Vol. II, Part III, Zoology Series, by E. P. Stebbing. (<i>Out of print</i>)	1	12	0
Note on the Economic Value of <i>Shorea robusta</i> (Sal), Vol. II, Part II, Economy Series, by R. S. Pearson	1	12	0
On the Structure and Biology of <i>Tachardia lacca</i> , Kerr, with observations on certain insects predaceous or parasitic upon it, Vol. III, Part I, Zoology Series, by A. D. Imms and N. C. Chatterjee	2	2	0
<i>Pinus longifolia</i> , Roxb., Vol. I, Part I, Sylviculture Series, by R. S. Troup	5	0	0

VII.—MANUALS.

Forest Zoology Manual, by E. P. Stebbing. (<i>Out of print</i>)	10	0	0
Manual of Botany, by R. S. Hole. (<i>Out of print</i>)	3	8	0
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